ELECTRICAL ENGINEERING

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The Cover: Dr. Harry F. Olson is at the keyboard of the latest development of the RCA Research Laboratories: the electronic music synthesizer. (See Brigadier General David Sarnoff's article, pp. 179–83.)

MARCH
1955

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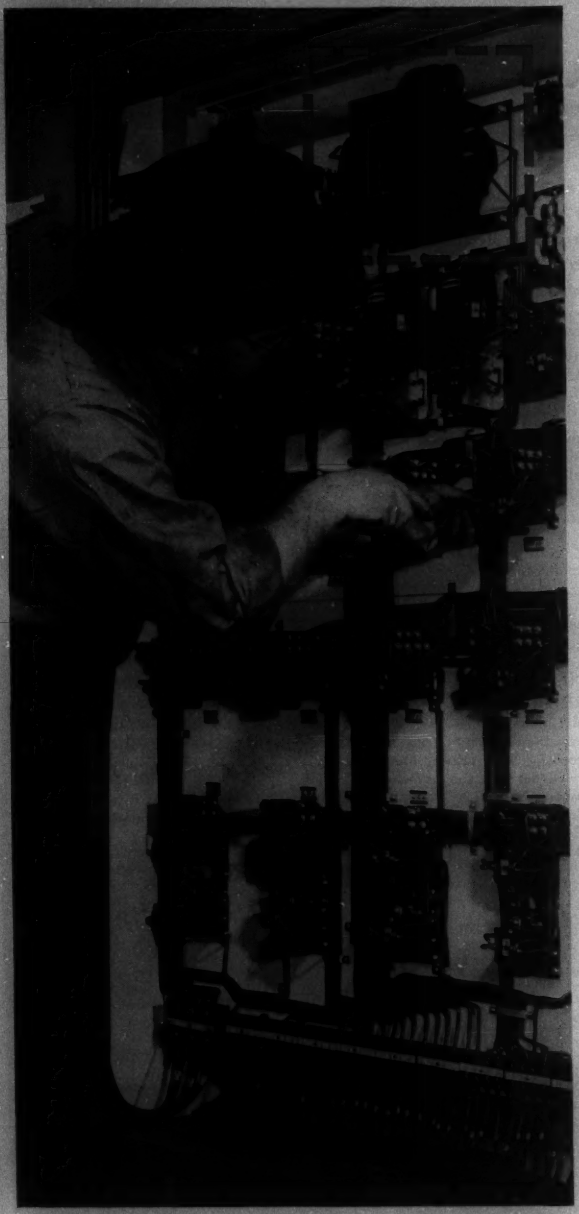

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HIGHLIGHTS.....

Building Our Future. President Monteith finds "...in all segments of the Institute an unprecedented awareness of the need for long-range planning." He tells of several new planning-for-the-future projects in his Winter Meeting address delivered at the General Session (*pp. 177–8*).

Harry Alonzo Winne—John Fritz Medalist. The presentation and acceptance addresses given at the John Fritz Medal ceremonies during the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955, are presented. The ceremonies included a history of the John Fritz medal, the life of the 1954 medalist, and the response of the medalist (*pp. 204–8*).

Research in the Electric Power Industry. "There is no question of the need for research. It is the key that has unlocked many secrets of nature for the benefit of mankind." The author believes that new developments and knowledge which lie ahead will dwarf the progress made to date (*pp. 200–3*).

Oliver Ellsworth Buckley—1954 Edison Medalist. The addresses of the speakers at the Edison Medal presentation ceremonies during the AIEE Winter Meeting. New York, N. Y., January 31–February 4, 1955, are given. The history of the medal, the life of the medalist, and response of the medalist are included (*pp. 209–12*).

Engineering Applications on IBM Digital Computers. Three typical examples illustrate the wide variety of engineering problems to which these digital computers may be applied with great speed and economy (*pp. 233–5*).

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New Developments in Electronics. Brig. Gen. David Sarnoff, chairman of the board, Radio Corporation of America (RCA), discusses a few achievements of RCA scientists and engineers which have resulted in new electronic developments of great promise for the future. The television magnetic tape recorder, electronic cooling system, electronic light amplifier, and electronic music synthesizer are described (*pp. 179–83*).

Transatlantic Telephone Cable. Cable and repeater basic design features are considered. Pertinent cable experiences receive attention before the transatlantic cable is described (*pp. 192–7*).

Photoconductive Detectors for Infrared Systems. The objective is to fill the hiatus in the field of conductivity between the work of the solid-state physicist and the practical requirements of the development engineer. Thus the important physical properties of the lead sulphide detector and suitable analytic expressions of its performance are stressed (*pp. 214–8*).

Electric Defibrillation. A-c defibrillation using a single application of 60 cycles is shown experimentally to be superior to either capacitor discharge of serial defibrillation for stopping ventricular fibrillation (*pp. 218–20*).

Textile Automation by Signal Control. This experimental development looks to the general control of textile machinery with ordinary 5-unit binary-coded paper tape and standard associated printing-telegraph apparatus (*pp. 238–42*).

Novel High-Tension Laboratory. This European laboratory has a 600-kv a-c plant, a 2,100-kv surge generator, and a 1,000-kv test set. The d-c generator contains a rectifier consisting of 64,000 selenium cells (*pp. 188–91*).

First National Conference on Utilization of Aluminum. AIEE's Power Division Committee and the Pittsburgh Section will jointly sponsor the First National Conference on Utilization of Aluminum at the William Penn Hotel, Pittsburgh, Pa., March 15–17. The program includes conferences on switchgear, transformers, regulators, reactors, rotating machinery, conductors, and general applications (*p. 259*).

Nuclear Reactor Control. This is neither a disclosure of new facts nor a review of published data, but rather a discussion of the fundamentals of present-day nuclear reactor control emphasizing problems facing electrical engineers who control them (*pp. 230–3*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Manufacturers' Research in Relation to Electrical Utilities. The role of the electric equipment manufacturers in research and development programs of concern to the utility industry is discussed. Typical activities in each of five specific areas are given attention (*pp. 184–7*).

Reactor Maintenance Problems. The widespread application of remotely controlled or automatically operated machinery has resulted in the transfer of a significant portion of the over-all manufacturing responsibility from operating to maintenance personnel. Experience with large production-type reactors is described here (*pp. 221–5*).

A-C Release of Thermoelectric Devices. Many types of gas fuel burners, dependent on a pilot flame, are available whose operations are controlled by a thermoelectric device. Continuous safe operation demands an uninterrupted flow of fuel to the device. A description of how this is done is given (*pp. 227–30*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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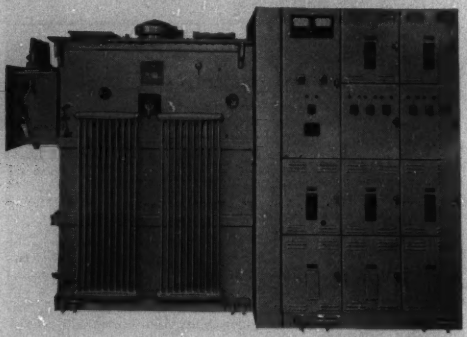

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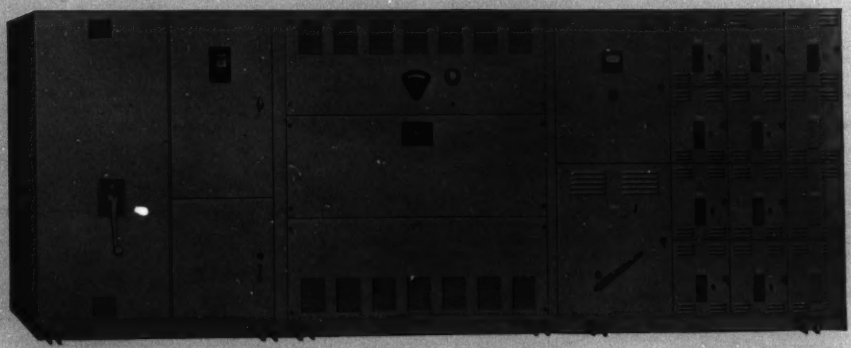

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Building Our Future

A. C. MONTEITH
PRESIDENT AIEE

President Monteith believes Institute membership will double in the next 15 years. Present membership, future projects, and particularly a unity organization to raise the professional stature of all engineers are emphasized in his Winter Meeting address.

I AM GLAD to report to you today that, in general, our Institute is going ahead smoothly and is in sound condition. I say this despite the impending financial problem which I discussed with you last October. Your Board of Directors hopes to reach a solution regarding this when it meets.

The most significant evidence of our healthy condition is the real progress we are making toward a firm foundation for an expanding future. This work is especially important now, since we seem to be at one of those critical crossroads that periodically occur in any fast-growing organization.

An organization such as ours must be progressive, or it will die on the vine. Since it lives on membership dues, it must serve its members—or, again, it will die. If it serves an area of the profession at all, it must serve it well. Because of our rapid growth and changing conditions, we should re-examine and reappraise our basic objectives and plan much further ahead than we have in the past. I am sure we are conscious of these responsibilities, because in all segments of the Institute I find an unprecedented awareness of the need for long-range planning. This has generated some new thinking and new ideas, which hold great promise for the building of our Institute's future. So I want to tell you a little about several of these new planning-for-the-future projects.

Any broad program of advance planning must be based on what you members are thinking and on what you want our Institute to do for you. The recent questionnaire on employment conditions, which 55% of you returned, was a good first step in this direction. We now know more than ever before about what you think on this subject. For example, analysis of the approximately 25,000 replies reveals such interesting things as these: 1. We are a reasonably young group of engineers. Well over half are under 40 years of age (57 per cent)—our largest age group is 31–50 years (33 per cent). 2. About 76 per cent work in industry, including utilities. 3. Regarding unions: about 5 per cent belong to a union; about 3 per cent are represented by a union, but do not belong to one; about 9 per cent definitely think they need collective bargaining—another 10 per cent are inclined to think they might need it; and about 70 per cent believe the work engineers do is incompatible with unionization.

In addition, 7,243 (29 per cent) of you contributed most helpful individual views and comments on your returns.

These are just a few high spots. I'm sure you found the analysis in the February *Electrical Engineering* of interest.

While self-sponsored questionnaires are helpful, probably they are not the best means for determining what you members believe the Institute should be doing in all its widely diversified areas of activities. Because there is increasing evidence that our Institute is outgrowing some of its traditional methods of operation, we need to find just what changes would be best.

We on your Board are busy with our own jobs and are able to give but little time to the Institute. Thus, none of us can devote enough time to study accurately members' wants; to draw up forward-looking aims and objectives, and then, without emotion, fear, or favor, set up an organization to serve these interests at minimum cost. The spending of a reasonable amount to obtain this information would be one of the soundest investments our Institute could make to assure a dynamic and vital organization, with sights squarely set on a target for the future.

After much study, consideration is being given to two moves. The first one is to conduct a scientific survey to secure an idea of what our members are looking for. I believe we are a long way from knowing the answer. The opinions and desires of our members are shifting, as evidenced by changes in meeting interest. These interests are affected by the times and economic situations. These interests should be followed.

The second is, based on survey results, to build an Institute organization that can serve these interests to best advantage. I believe an outside consulting firm which specializes in organization should study the Branch, Section, General Committee, Technical Committee, Publications, and our other operations. With a good definition of our objectives before them, the consultants could make a recommendation for an organization that would best serve the memberships' interests. Whether or not we accepted all recommendations would, of course, be up to us.

I think you will agree that now is the time to have a thorough objective look at ourselves. We won't like some of the answers, but we can cross those bridges one at a time when we have the course plotted.

Both the scientific opinion survey and organization study bear on the Institute as a whole. But just as important are the constructive, long-range planning projects initiated by many of the individual Institute committees. For example, on the technical side: planning and organizing

A. C. Monteith is vice-president in charge of engineering, Westinghouse Electric Corporation, Pittsburgh, Pa.

Text of the presidential address presented at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955.

far enough in advance for smoother transition of committee leadership brings with it the real possibility that perhaps twice as many members could serve as committee officers. Also, increasing cultivation of special technical conferences and enlisting co-operation of other societies will minimize the formation of splinter societies. Additional long-range planning projects include: clarifying the long-range objectives of the Institute in its standards work; arranging for all General Meetings at least 5 years in advance; correlation with other major societies to avoid serious conflicts in dates; launching of a continuing effort to attract new major honors and awards; re-evaluation of membership requirements to make them more equitable in the years ahead; realistic reappraisal of our district geography.

There are many other projects, but these show how our members are raising their sights to plan not only for next year, but 5 or 10 years ahead. As I stated last October, we may well double in size in this period. We must take steps now to build an organization that can serve such a membership.

In addition to things like these we are doing ourselves, certain outside activities bear directly on our future well-being. These range from how the military classifies future technical graduates, to the new engineering societies' building project. But in my opinion, the most important project before the engineering societies today is to work toward a unity organization with a much broader base than now accomplished.

You may recall that based on an expression from our membership, several years ago our Institute took a definite position on this unity problem. The Institute policy adopted by your Board of Directors, June 15, 1950, reads: 1. To work continually for the unification of the profession. 2. To recognize the fact that the Institute finds its chief reason for existence in the technical field. 3. To handle questions on nontechnical affairs as necessary and as they arise, on an emergency basis until, through unification, they can be handled on a general professional basis. Incidentally, this policy appears in the 1954 "Year Book," page 609.

In general, the engineering societies have done a wonderful job in the area of promoting technical progress and standardization. These societies are now organized basically along technical lines—as is AIEE. However, I believe our policy is not fully understood by our membership, as I have received many queries from our members asking what we are doing about raising the professional stature of our members. In keeping with our policy, we have been doing some work within our committee structure and have been actively supporting the Engineers Council for Professional Development. But both of these, combined, are not sufficient.

Either we should have a unity organization that will undertake the professional phase of the work that is common to all engineering branches, or we should organize to accomplish this in our own structure. I would be sorry to see the latter become necessary. The organization your Board of Directors thinks necessary, and on which the Board considers it has a mandate from you, must accomplish two things: it must tie the technical societies together in broad technical matters and, it must speak for the engineering profession on broad matters such as manpower, the promotion of engineering education, nonunionization of engineers, and professional development.

When the reorganization of Engineers' Joint Council (EJC) was under consideration some years ago, the matter of organization for unity was submitted to our membership. Our membership strongly supported a plan that had two parallel branches—one professional, and one technical, but tied together with an over-all board of directors. This would result in an over-all organization starting at the grass roots, with individual members having a vote and a voice in governing the profession as a whole. It would still leave to the technical societies—which would be combined in the other branch—the promotion of the technical phases in which they have done an excellent job. This was known as "Plan C."

Your Board of Directors and representatives on EJC finally went along with the idea that EJC would start as a federation of societies, securing as many participants as possible. These participants would then work together to formulate the final unity organization that would best serve the profession. EJC now has eight member societies, representing 170,000 engineers through their respective societies. Your Board, based on your mandate, is asking for the appointment of a committee in EJC to plan a course which would allow EJC to evolve into an over-all organization with adequate financing and with power to act promptly when required. It would be based upon individual membership rather than be a council of societies.

Since Plan C—the one you endorsed—does not seem acceptable, a second plan has been suggested. It is the hope that a compromise can be worked out that would not sacrifice the basic points that you originally desired. This plan suggests that there be two autonomous branches: one professional in nature, and one technical in nature, and each selecting representation for an over-riding board of directors. The new organization could be called "The American Engineering Association." The professional as well as the technical branches would be made up of individual members with the right of vote and determination. Membership would be common in the two branches.

The second plan is very similar, in general nature, to the American Medical Association, which has been in successful operation for many years. By referring to this association, however, I hasten to say that no one has suggested that such an organization structure be accepted in its entirety. Rather, it should be studied to take full advantage of the proved and successful parts of the program that would fit the engineering profession.

Thus, we report to you now that your representatives are still pressing for a plan of evolution of EJC that would give it increased professional stature. We will keep you advised from time to time on our progress—or the lack of it—as it may be necessary to review this matter with you to evolve a final plan acceptable to you.

I want to commend you for the excellent long-range planning you are doing. The years to come will prove your present effort to be of lasting value to our Institute and to the profession.

New Developments in Electronics

DAVID SARNOFF
FELLOW AIEE

Since the advent of the vacuum tube we have become accustomed to marvels coming from research laboratories. There have been tape-recorded color television, a light amplifier, an electronic cooling system, and the latest: an electronic music synthesizer.

JUST 53 years ago—in January 1902—the AIEE held a banquet to honor a young man of 27 named Guglielmo Marconi who, a month earlier, had received the first transatlantic wireless signal.

It is interesting to look back on that historic event for a brief moment. It gives us, almost in the form of a tableau, a dramatic illustration of how our predecessors in this Institute did so much to get wireless telegraphy as well as many other inventions "off the ground."

On the dais with Marconi sat Alexander Graham Bell, Michael Pupin, Elihu Thomson, Charles Proteus Steinmetz, T. C. Martin, and other famous men of the electrical field.

The ovation for Marconi was thunderous, and after it subsided a message was read from Thomas A. Edison, who said:

"I am sorry not to be present to pay my respects to Marconi. I would like to meet that young man who has had the monumental audacity to attempt and succeed in jumping an electric wave across the Atlantic."

A salvo of applause greeted the youthful Italian as he arose to express his gratitude. Speaking with a modesty almost amounting to diffidence, he recalled the disappointments he encountered as a pioneer, and said:

"I feel myself highly honored to be entertained by such a great body as the American Institute of Electrical Engineers. I think it is well known all over the world that Americans stand first in applied electrical engineering. I feel myself greatly honored to be in the midst of so many eminent men whose names are household words in the whole civilized world."

After a description of his wireless, he expressed the hope that he might bring his work to a successful completion, and with that he proposed a toast to the AIEE.

This memorable event in our history is a splendid example of what faith and encouragement have meant not only to Marconi, but to many other explorers in the electrical domain during the 71 years of the Institute's life.

The honors conferred by the AIEE are cherished by the deserving recipients comprising a roster of men who made immortal achievements during the past two generations.

The hallmarks of the Institute have been courage and vision. Its members have never feared obsolescence nor frowned upon new inventions which threatened revolutionary changes. From such faith have sprung great new industries and services to America and to all the world.

My own faith in the creative abilities of scientists and engineers has been boundless. At times I had more faith in some of them than they had in themselves. All they needed to increase confidence in themselves was the awareness that others believed in them and in their ideas along with evidence of practical and moral backing.

In my years of association with scientists and engineers

Essentially full text of an address presented at the general session of the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955.

Brig. Gen. David Sarnoff is chairman of the Board, Radio Corporation of America, New York, N. Y.

I have acquired a deep respect for their creative faculties, their constant search for knowledge and facts, and for their integrity of purpose. I have tried in my small way to stimulate and encourage them in their work, to share with them their dreams and disappointments, and to rejoice with them in their triumphs.

Today, I should like to discuss with you some recent end-products of that creative urge—a few achievements of the Radio Corporation of America (RCA) scientists and engineers which have resulted in new electronic developments of great promise for the future.

TELEVISION MAGNETIC TAPE RECORDER

The television magnetic tape recorder has been produced and demonstrated in both color and black-and-white (see Fig. 1). It is now being installed in the National Broadcasting Company (NBC) where it will undergo a series of field tests. These tests will help us to determine the commercial design of the apparatus best suited to meet the needs of television broadcasting.

This new type of tape recorder can provide useful services not only in television broadcasting but also in the motion picture and theatre industry, in home entertainment and education, and industry in general. An unlimited number of copies of tape recordings can be made quickly and economically. The recorded tapes can be preserved indefinitely or electronically "wiped off" and reused again and again.

Television tape recorders for home use are certain to be developed in the future. These will enable the television set owner to accumulate a library of favorite television programs which can be seen whenever desired, in the same way that a library of phonograph records now makes it possible to hear favorite records at will.

The achievement of television magnetic tape is a major step into an era of "electronic photography." Motion pictures in color and black-and-white can be produced quickly and economically without any photographic developing or processing. Pictures can be viewed the instant they are taken, thus adding new flexibility to the making of motion pictures.

Fig. 1. The RCA television magnetic tape recorder heralded by General Sarnoff as opening a new era of "electronic photography." Here is shown the apparatus with which television pictures in both color and black-and-white can be impressed on tape

ELECTRONIC COOLING SYSTEM

The electronic air conditioner, designed without any moving parts, motors, or compressors—in fact, a noiseless machine—is on the way, and encouraging progress is being made in our laboratories. In effect, it is an all-electronic cooling system, and the small electronic refrigerator, shown in Fig. 2, is the first result of research in this field. To the best of our knowledge it is the first refrigerator to achieve practical storage and freezing temperatures entirely by electronic means.

The principle on which this electronic cooling system operates has been known to scientists for more than 120 years. It was the French physicist, Jean Charles Peltier, who discovered that passage of an electric current through the junction of two dissimilar materials produces a cooling or heating effect in the region of the junction, depending upon the direction of the current.*

This so-called "Peltier effect" has long been a scientific curiosity chiefly because of the lack of materials capable of producing temperatures sufficiently low for practical use in cooling or refrigeration. Unlike Peltier, Lord Kelvin, and others who studied this effect, the RCA scientists were able to approach the task with new knowledge provided by recent studies in solid-state physics. Their research in this field shed new light on the behavior of electronics and solid materials, and provided new information which has led to success in creating new materials. The discovery of Peltier has now been translated into practical application. Our continuing search for improved materials so far has revealed no evidence that a limit has been reached.

Encouraging progress is being made in the development of this cooling system which will enable construction of a noiseless electronic air conditioner in a self-contained unit such as required in the home.

ELECTRONIC LIGHT AMPLIFIER

In still another new field, our scientists and engineers have made substantial progress in the development of an electronic light amplifier. I have already seen an experimental RCA light amplifier that gives light amplification in ratios of more than 20 to 1. (See Fig. 3.) When that figure reaches 100 to 1, a practical amplifier of light will be at hand. We will also have made a significant advance in

* Prior to the research program undertaken by RCA Laboratories, the best performance known to have been achieved with the Peltier effect was a lowering of temperature by 9 C. The new alloys developed by the RCA research team and used in the refrigerator achieve a temperature drop several times greater, and the continuing quest for improved materials so far has discovered no indication that a limit has been reached.

the science of illumination for lighting and for television picture reproduction.

Ultimately, through the application of electronic light, the present television picture tube will be replaced by a thin flat screen that can be hung on the wall like a picture. That will be "mural television," with the screen under complete control of a little box. Indeed, simplicity, compactness, and flexibility will be the features of television in the future. The electronic light amplifier and tiny transistors—also products of recent electronic developments—will eliminate the need for using the picture tube and all other electron tubes in a television set.

ELECTRONIC MUSIC SYNTHESIZER

THERE is another development under way in our laboratories which I should like to cover in a little more detail because this is the first time it is being publicly disclosed. We call it the "RCA Electronic Music Synthesizer."

During the past 50 years we have learned that electricity, once looked upon as unrelated to the arts, is really a close kin. In radio broadcasting and television, in the modern phonograph, and in sound movies, music and literature have been electrified and electronized visually as well as audibly.

The scientists and engineers in RCA Laboratories have been experimenting for some time in an effort to broaden the creative scope of composers and musicians by enabling them to take advantage of scientific developments that can be applied to music.

The physical properties of sound are frequency, intensity, waveform, and time. The psychological characteristics of sound which depend upon the physical properties are pitch, loudness, timbre, and time. Every sound in nature may be described in terms of these attributes of sound or tone. Sound waves, of course, comprise the medium of transmission from the musician, or musical instrument, to the listeners; and a tone is a sound wave capable of exciting an auditory sensation having pitch.

The operation of the RCA electronic music synthesizer is based upon the breakdown of a tone into its characteristics such as frequency, intensity, growth, duration, decay, portamento, timbre, and vibrato.

For an electronic instrument to handle with fidelity all of these characteristics of tone has presented a great challenge to our research men, but our scientists and engineers have succeeded in developing an electronic system that, even in its present stage of development, achieves extraordinary results, We believe that further advances will bring this new system to a stage of practical usefulness in the world of music.

The research and development work on this project is under the direction of Dr. Harry F. Olson, director of the Acoustical and Electro-Mechanical Research Laboratory, Princeton, N. J. (See front cover.) Dr. Olson is recognized throughout the world as an outstanding authority in the field of acoustics. He said:

"We have been able to create an electronic system capable of generating any tone produced by the human voice or any musical instrument, as well as any musical tone which is beyond the capabilities of a voice or conventional instrument. The RCA electronic music synthesizer is a means for producing electronically an infinity of new musical complexes employing the sound of human voices and conventional instruments, or tones that may never before have been heard, either in solo performance or blended in any desired orchestral arrangement. The synthesizer system permits us to perform electronically the translation of the composer's score into sound and to create any sounds that may have musical significance."

Fig. 2. Development of an all-electronic cooling system by RCA has led first to this experimental model of an electronic refrigerator. Nils E. Lindenblad of RCA Laboratories is shown here explaining the instrument believed to be first refrigerator to achieve practical storing and freezing temperatures entirely by electronic means

This new system of making music should encourage musical composers to write new compositions that can take advantage of the wider scope and superior characteristics offered them by electronics for the expression of their genius. In this new role, electronics performs in marked contrast to the musician whose playing is limited to the use of ten fingers and sometimes also the two feet.

This electronic instrument is shown in the title picture with Dr. Harry F. Olson of the David Sarnoff Research Center of RCA, Princeton, N. J., at the keyboard, and Herbert Belar at the control panel. The function of the instrument is basically two-fold: to synthesize familiar sounds and to create an unlimited range of tone variations. It has a capacity for originating endless varieties of rhythms and also offers new opportunities for production of phonograph records, since it can produce any kind of sound that can be imagined. Further, old

Fig. 3. General Sarnoff at the Princeton Research Center of RCA, which bears his name, watching the demonstration of the RCA electronic light amplifier which he said will have important applications in television, radar, X ray, and other fields

recordings can be rejuvenated into new phonograph records, free from distortion and noise.

It is not necessary that a composer be able to play a musical instrument, for whatever musical effects he wants to create he can achieve by use of the synthesizer.

But the vital factors of correct "interpretation" of the music written by the composer—the heart, the soul, and the mood of the composition—continue to be the task and function of the human being who synthesizes the music from the score. That person must be a good musician. As Dr. Olson has said, "In the hands of a great musician the electronic synthesizer can create great music."

When I first heard this machine, many of the musical notes sounded so new and strange to me, that I wondered whether Maestro Toscanini, Jascha Heifetz, or Richard Rodgers would be needed to produce music with this new system. But the research men tell me that while the machine does not turn engineers into composers, conductors, or instrumentalists, it does enable them to become interpreters of music. For example, they can take the musical score of a great composer, key it through the synthesizer and obtain results that would be achieved by musicians playing their conventional instruments. The men who operate the synthesizer need not know how to play any musical instrument; they can simulate instrumental artists by merely pressing typewriter-like keys that actuate electron tubes and transistors. (See Figs. 4 and 5.)

A MUSICIAN'S APPRAISAL

Recently I invited Alfred Wallenstein, conductor and music director of the Los Angeles Philharmonic Orchestra, guest conductor of the NBC Symphony Orchestra and former solo cellist with the New York Philharmonic and Chicago Symphony Orchestras, to visit our Princeton laboratories and witness demonstrations of this system. I asked him to discuss its functions with the inventors and to give me the benefit of his professional judgment. He graciously accepted my invitation and went to Princeton. He spent several days in discussing this development with our scientists and engineers and in hearing and seeing the electronic music synthesizer perform. I quote only a few of Mr. Wallenstein's statements:

"Development of an electronic instrument with an unlimited variety of tone colors and an unlimited capacity for rhythmic variety is a step that cannot fail to challenge and stimulate human imagination. Depending upon the perfection of the process, an entirely new concept of what is musically usable can be evolved. In my opinion, the function of such an instrument is two-fold—to synthesize familiar sounds and to create experimentally an endless new variety of sounds. Indeed, the entire world of sound can be tapped for the creation of yet unheard musical forms.

"There is no question that if perfected and made thoroughly responsive, the electronic music synthesizer can become a veritable fountain of inspiration and new ideas not only because endless new timbres can be invented, but also because realization of any pattern, no matter how rhythmically, melodically, or harmonically complex and extensive becomes possible through the series of routine manipulations. It can synthesize voices from the past, such as Caruso's great voice, creating the accurate timbre, and then reconstructing an aria from some opera."

Mr. Wallenstein concluded:

"In its present state the electronic system of synthesized music is not at a point where it can replace or personalize live artists or orchestras. However, the ideas expressed for further development of this system, when realized, should make it possible not only to expand the boundaries of music, but also to achieve musical results that can now be achieved only through human hands and voices and with existing musical instruments."

A short film of the synthesizer demonstrates the results achieved on conventional magnetic tape records by engineers at our Princeton Laboratories, who are not musicians. They employed no instrumentalists and used no musical instruments in any of the music.

The musical selections from which the excerpts have been synthesized and the musical instruments simulated are the following:

	Excerpts from Selections	Composers	Musical Instruments Simulated
1.	"Well-Tempered Clavichord"	Bach	Clavichord
2.	"Polonaise"	Chopin	Piano
3.	"Clair de Lune"	Debussy	Piano
4.	"Hungarian Dance No. 1"	Brahms	Engineers' conception (No instrument simulated)
5.	"Holy Night"	Adams	Electronic Organ
6.	"Home Sweet Home"	Bishop	Engineers' conception (No instrument simulated)
7.	"Medley"	Foster	Hillbilly Band
8.	"Nola"	Arndt	Ultra Piano
9.	"Blue Skies"	Berlin	Orchestra

STIMULUS OF COMPETITION

You may wonder what philosophy prompts me to reveal these new developments publicly while they are still in the experimental stage. Why do we not wait until they have been completed as commercial products? My

answer is simple. Competition can be as stimulating in research as in manufacturing and merchandising. As members of a profession deeply concerned with scientific research and pioneering development, you are well aware that the number of people willing to risk their money in research and pioneering is very small compared with those who are ready to risk their capital in established enterprises operating profitably.

In television and in other instances—where the information is not "classified" and does not involve our national security—RCA has continually made progress reports and released information that enabled others not only to catch up but at times even to move ahead of us. We welcome competition. It spurs our own activities and increases the possibilities for earlier achievement of desired results.

For instance, our faith and persistence in pioneering television—first, black-and-white, and then, color—and our encouragement to others to get into the field, led to its present state of development which otherwise the American public might not have enjoyed for another 10 years.

Whether we succeed in completing an invention before others whom we stimulate to work along similar lines is not as important as it is to bring a new product or a new service into existence and use. In helping industry to grow and prosper, we believe that we contribute to the public benefit and in the long run, our own as well. If an organization is to progress, it must not stand in fear of obsolescence or competition.

Electronics, in the race to achieve new triumphs, is run on the big track of time, on which there is room for all who would compete. There is no finish line.

ALLIANCE OF SCIENCE AND THE ARTS

HAVING BEEN INTRODUCED to these several new developments that closely relate science to the arts, it must occur to you that the day is here when the engineer and the artist should join forces and seek to understand the terminology and problems of each other in order to advance together.

Fig. 4. The keyboard and punched paper record of the music synthesizer are shown. The keys are colored to simplify operation for recording note selection, octave, timbre, growth, duration and decay, and volume. The paper record moves at the rate of 5 inches per second

Fig. 5. In the recording system of the music synthesizer, each individual instrument must be recorded separately by the six reproducing heads visible, and then combined into a single recording on the lower disk

If you will form an intellectual camaraderie and arrive at a common language with your colleagues in the arts so that they can learn how to make full use of science and technology, you will see the fruits of your genius bloom in the vineyards of the cultural arts. The liberal arts should not shrug off advances in science and technology as too technical to understand, and engineers at their end should not regard music and the arts as outside their natural domain.

For more than a quarter of a century, the entertainment arts have felt the magic touch of electronics. As a result, music, drama, motion pictures, the phonograph, and even journalism have taken on new dimensions. New interest has been created in them and their audiences have multiplied from thousands to millions.

The music synthesizer aptly illustrates how important it has become for the electronics engineer and the musician to understand the achievements and objectives of each other. The same is true for all men and women in the physical sciences in their relationships to those who are working in the humane sciences.

Medical men must also become better acquainted with the scientists and engineers in many phases of atomics and electronics so that the isotopes, color television, electron microscopy, and similar developments can be applied effectively and quickly for the welfare of mankind and the extension of life's span.

For the good of America and the world in general, the arts and sciences are challenged to work together and bring their respective talents and skills into focus. In effect, men of science and the arts must play on the same team and understand each other's signals so they can score together.

I am gratified that it has been my privilege to unveil before this particular audience these new developments in the challenging field of electronics. I am proud to be one of you.

Manufacturers' Research in Relation to Electrical Utilities

E. E. PARKER
MEMBER AIEE

J. BAIRD
MEMBER AIEE

Research and development go together in any industry. In the electrical utilities field their areas cover basic scientific knowledge and power generation, distribution, and utilization. Although this industry has made giant strides ahead, progress demands continued research.

ENGINEERS have a two-fold function. They must find ways to increase the value of present products, and they must develop new products. Similarly, any healthy industry must also do the same and certainly the electrical utility industry is no exception.

Since research and development are vital to the production of products of increased value and the creation of new products, adequate work of this character is essential to the continued growth of the electrical utility industry. Thus, the question becomes immediately not one of justifying research and development but rather one of determining the appropriate areas for research and development to support the utility industry, of deciding how much should be done, and finally of finding out who can best do the work.

With respect to the interests of the electrical utilities, appropriate areas for research and development include:

1. Basic scientific knowledge.
2. Power generation.
3. Power transmission and distribution.
4. Power system analysis.
5. Power utilization.

Deciding how much work should be done in these areas calls for a quick look at the present situation. The availability of adequate amounts of electric power at reasonable and constantly diminishing costs has been a major factor contributing to the high standard of living in this country. The electrical utility industry has performed an amazing feat in reducing the average cost of domestic electric energy by 32 per cent[1] in the last 15 years, a period during which the cost of living has risen by 93 per cent.[2] In addition to cost reduction, there has been an increase in value of the electrical utilities product through significant improvements in reliability, voltage control, and frequency control.

But while there is reason to be proud of this, the industry cannot afford to be satisfied, for as in all technical fields, continued progress demands continued research effort.

This work will be done by the utilities, consulting engineers, universities, independent research groups, and the equipment manufacturers. It is the purpose of this article to examine the place of the electric equipment manufacturers in research and development programs of concern to the utility industry. This will be done by describing typical activities in each of the five areas outlined previously. Since conditions surrounding research and development in the industry are not expected to be appreciably different in the future than at present—if the special situation of atomic energy developments can be considered separately—the pattern of manufacturers' research and development now in progress should be a reliable guide for the future. Since the industry is expected to expand, the amount of research and development should increase proportionately.

Underlying this article are certain fundamental premises. For clarity, these will be set forth at this time:

1. The electric equipment manufacturers are in an excellent position to make substantial contributions in research and development for the utility industry.
2. They have the double motivation of wanting to sell not only the equipment for generating and transmitting power but also the equipment that uses this power.
3. They operate in a competitive climate of the private enterprise system where the worth of research and development work must be proved or it will be discontinued.
4. A great percentage of all applied research and advance development is applied to physical things, and the manufacturers of these things are in an excellent position to understand what work is needed and how best to do it.
5. And, finally, the equipment manufacturers have reason to be proud of past contributions, although they are mindful that these contributions were made possible by encouragement and active co-operation from the electrical utility industry. In many cases the utilities have assumed leadership through specifying equipment having characteristics superior to that in production.

Because of the competitive situation in the manufacture of electric equipment, it can be anticipated that the manufacturers will continue to expand their research and development activities in almost every phase of work applicable to the electrical industry as a whole. This is essential if they are to increase the value of their products and develop new products—a necessity for survival in a competitive economy.

This is not to say that the manufacturers do not welcome programs sponsored by the utilities. Indeed, they do. Certainly no one can say that too much research can be done, in view of the ever-expanding horizons of science.

Nor is it the purpose of this article to say that all areas vital to the growth of the industry are being adequately

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covered by existing research and development programs. This symposium is to explore ways in which research of specific interest to the utilities may be accomplished. The areas involved include science, power generation, power transmission and distribution, power system analysis, and power utilization. The purpose of this article is to discuss the type of work the manufacturers are doing in these five areas and how much can be expected from the manufacturers in the future, based on recent accomplishments.

For use herein, "research" is considered to mean the quest for new knowledge, new processes, and new materials. It includes basic scientific research with no definite device or application in mind and applied research in which the feasibility of applying scientific principles is proved for a specific purpose. The term "development" is advanced development engineering, including the development of an engineering model of a device. These definitions will be applicable throughout the following discussion of manufacturers' work in the five areas listed previously.

BASIC SCIENTIFIC KNOWLEDGE

Conductors, insulators, and magnetic materials are three basic building blocks for all electric equipment. The nature of their behavior has never been wholly understood. Today in the electrical manufacturing companies' laboratories a large amount of research is devoted to obtaining better understanding of the nature of conduction, insulation, and magnetic phenomena.

Probably no utility will ever operate any equipment at −440 F, yet much research work is being done on the phenomenon of superconductivity below this temperature. At these temperatures near absolute zero, some metals lose all their resistance and refute many commonly held theories of conduction. New knowledge of superconductivity may give a better understanding of how electricity is conducted at room temperatures and provide new information about the basic structure of matter.

Considerable progress recently has been made in understanding the fundamental nature of insulators, and if history is any guide, this work should eventually provide the basis for the development of better insulating materials. When chemists learn how molecules of various substances affect the characteristics of synthetic dielectrics, they may be able to synthesize improved solid, liquid, and gaseous insulators. A related area of basic electrical research, with broad implications for utilities, pertains to corona phenomena, including the effect of corona on insulation. Results now being obtained should provide necessary background for the improvement of many pieces of electric equipment.

Many of the magnetic materials now in use are the result of equipment manufacturers' research and development programs. While these materials are vastly superior to their predecessors, there is still appreciable room for improvement which can only be brought about by continued work in the laboratories of the world. For example today there is a much better understanding of the basic mechanism of ferromagnetism, yet in the manufacture of electrical steels there is an incomplete understanding of how magnetic properties are influenced by various factors such as rolling, temperature, and grain size.

Significant work is being done in the area of the structure of metals. The object is to determine why metals behave as they do, with emphasis on failure under stress. In the study of certain important materials, test samples with small cross sections have exhibited, under some conditions, much higher strength per unit area than large pieces of the same geometrical pattern. The need for knowledge of this phenomenon increases directly with the demand for larger equipment and high design-stresses. Single-crystal filaments of a large number of different metals and compounds have been grown and submitted to extensive physical tests. In the case of iron, strengths of up to 1,000,000 pounds per square inch have been obtained in single-crystal filaments. While this strength is currently of little engineering value due to the small size of the filaments, it may lead indirectly to the development of new high-strength high-temperature alloys with vital applications in the utility industry.

Only a few examples of the manufacturers' research programs of direct or indirect benefit to the utilities have been discussed. There is also important research in the development of new light sources, arc phenomena, electron irradiation of materials, semiconduction, nuclear science—to name some of the more important.

POWER GENERATION

An area where the contribution of the electrical manufacturers can be readily measured is the development of improved steam-electric generating equipment. A significant portion of the real cost-cutting enjoyed by the consumer of electric power has come about through increased steam-electric generating-plant efficiencies. Fig. 1 shows a plot of the trend of coal consumption per kilowatt-hour for the steam-electric generating plants in the United States during the past 50 years. The upper curve shows the average coal consumption rate of all plants, while the lower curve shows the coal requirements of the best plant in service in any particular year. These two curves are based on the utilization of coal with the heating value of 12,500 Btu per pound. Continued improvement in steam-electric generating-station efficiencies is tied inti-

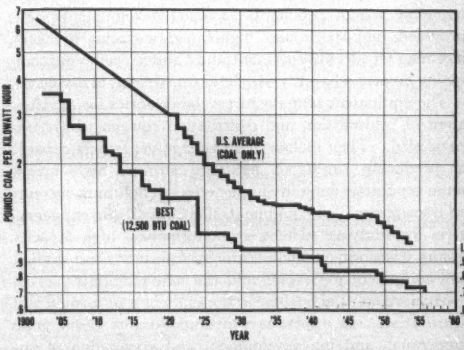


Fig. 1. The United States' steam-electric generating-station coal rate for the past 50 years

mately to research in such fields as metallurgy and combustion and to the development in equipment designs.

In addition to basic research there is a large amount of work in the fields of material and process development together with work to extend the knowledge of the engineering sciences all directed toward improvement in power generation equipment. Examples of this are the search for new materials, for new knowledge of how to better apply available materials, and for improved dynamic, thermodynamic, and mechanical designs. Study of fuel combustion recently has been emphasized in the research and development laboratories of the United States. This may lead to self-pressurized combustion, eliminating induced- and forced-draft fans as well as reducing boiler sizes.

The search continues for new thermal cycles, with the goal of increased value to the customer. Work on the commercial gas turbine falls in this area.

At least a brief comment must be made on the application of atomic energy to the utility industry. This differs from the areas already mentioned in that the major research expenditures are being made by the Federal Government, and the magnitude of these expenditures is so very large that atomic research by manufacturing companies would be small in comparison. Governmental restrictions, while entirely justified, have also limited freedom of effort in this area. Despite this fact, the equipment manufacturing companies are attempting to stay abreast of the field and to create a pool of trained manpower through two approaches: by conducting government-sponsored atomic energy research, and by expenditure of their own funds to solve specific atomic energy problems.

TRANSMISSION AND DISTRIBUTION

Two foundations upon which the modern utility system has been built are economical and reliable transmission of power over appreciable distances at a reasonable cost, and economical systems for local distribution. The electrical manufacturers have devoted, and will continue to devote, much time and money to research and development in this area. In the past, this work has resulted in improved insulators, new understanding of corona and arc phenomena, and fundamental knowledge of power transmission and distribution system problems. Typical developments have provided high-speed and high-capacity circuit breakers, lightning arrester improvement, and transformer designs combining greater reliability with less cost, weight, and volume.

The equipment manufacturers' laboratories for development of transmission and distribution equipment are unparalleled. They include high-voltage generators capable of producing simulated lightning strokes, high-current surge generators for studying the effect of lightning currents on transmission line equipment, short-circuit current generators for studying switchgear performance, high-capacity testing transformers, facilities for transformer noise studies, and equipment to develop and test new materials.

Much remains to be done in the study of transmission and distribution. Examples are investigations of radio noise suppression and the development and application of improved dielectrics, magnetic materials, and economical designs for higher capacity circuit breakers that will almost certainly be required in future system interconnections. The development of a computer for remote reading and automatic billing of all types of utility meters offers an engineering challenge. However, it appears doubtful that the present general pattern of transmission and distribution will be upset, although possible extension of underground systems, making use of improved dielectrics and cable construction, must not be overlooked.

SYSTEM ANALYSIS

System analysis, or system planning as it is frequently termed, is an area where the electrical manufacturers may be of help to the utilities, but where responsibility inherently rests with the utilities. Utility effort in this area, on the part of their own engineering staffs or through the services of consulting engineering firms, is advantageous to manufacturers since such studies normally point the need for the development of improved system equipment.

Even though basic direction for system analysis must come from the utilities, the engineering staffs of the equipment manufacturers are able to make appreciable contributions due to their specialized experience and facilities. In order for the utility to obtain maximum advantage from such service by the equipment manufacturers, it must maintain a competent staff capable of understanding and contributing to the solution of system analysis problems.

While most utilities individually support system analysis operations, co-operative research and development among groups of utilities has been evident. This is being done to some extent at present for regional planning, in the use of network analyzers, and in the solution of other operating problems of mutual interest such as the economics of high-voltage transmission interconnections.

The complexity of the technical and techno-economic problems, many of which have political overtones, is constantly increasing. There has been a new tool, or perhaps it is more accurate to say concept, developed immediately prior to and during World War II which holds much promise to improve the effectiveness of managers by applying a systematic approach to management problems. Thus the manager may base his decision and action on facts developed through a systematic method rather than on personal experience. It is essentially the application of engineering techniques to the problems of management. This method has become known as operations research.

There have been many definitions of operations research given, perhaps because it is a method normally consisting of several steps so that it is difficult to give a comprehensive definition in a sentence or two. The following by Morse and Kimball[2] will serve the purpose:

"Operations research is a scientific method of providing executive departments with a quantitative basis for decisions regarding operations under their control."

In engineering terms, operations research could be said to be the application of the engineering method of problem solving to the problems which arise in operations. This engineering method essentially consists of:

1. Stating the problem.

2. Gathering all available data and facts.

3. Constructing a conceptual model which is frequently but not necessarily mathematical.

4. Where pertinent, the solution of the mathematics and application of boundary conditions to obtain a relationship of variables.

5. Interpretation of results in view of completeness of data and simplifying assumptions.

Many of the methods of operations research already are being used by the utility industry.[4] These methods unlock a great storehouse of human knowledge so that it may be successfully applied to situations which up to the present time have been considered too chaotic, complex, or uncertain for any but intuitive solutions based on personal experience.[5]

POWER UTILIZATION

THE very rapid increase in power consumption has been a major factor in the lower cost of electric power. For example, increased demand for power and the interconnection of power systems have permitted the installation of larger generating units with higher efficiency and lower labor and maintenance costs.

Both the wider use of existing devices and the development of new devices which depend upon electricity for power have contributed to the load growth. Devices that are important new load builders include air conditioners, television, household clothes driers, and the heat pump. In the industrial and commercial area, many developments such as new light sources and lighting techniques and new electric equipment for use in electrometallurgical and electrochemical processes contribute to power demands. Many of these devices have been the product of manufacturers' research and development efforts, thus serving the interest of both manufacturer and utility.

CONSIDERATIONS FOR RESEARCH EXPENDITURES

MANUFACTURERS of electric equipment generally have taken a very broad view of the indirect benefits resulting from research and development expenditures rather than demanding that all expenditures be tagged to particular products. This has resulted in large and continuing expenditures in areas where the major return comes through general expansion of the electrical industry. Such efforts have included, in addition to fundamental research in the physical sciences, theoretical studies on power system stability, studies on the vulnerability of transmission lines to lightning damage, the continuing program for improvement of residential and industrial lighting practices, etc.

Liberal policies on research expenditures permit better integration of programs and allow the inclusion of work which could not otherwise be done. For example, work on improved dielectrics is supported by continuing studies on the theory of dielectrics and on corona effects in dielectrics. However, the liberal policies place an increased burden on the judgment of the personnel directing the work.

From the manufacturers' viewpoint there appear to be many areas where research and development expenditures by the utilities would be more fruitful than in direct equipment development programs of the type carried on by the electrical manufacturers. One of the many examples of utility research was the study of steam-boiler water treatment, a program that effectively augmented the work in boiler and turbine design conducted by the manufacturers. In addition to this type of research, closely correlated with manufacturers' efforts, there will continue to be many system problems in connection with the expansion of the country's power requirements. Solution of system problems will be directly dependent on research and development programs conducted by the utilities.

LOOKING AHEAD

RESEARCH and development programs may be divided into two general classifications: first, an evolutionary area, and second, an area where new concepts alter the basic way in which a particular task is accomplished. This latter could be considered as a revolutionary area.

In the evolutionary category could be included all improvements in existing classes of equipment though some may involve revolutionary concepts to improve an old idea or device as the magnetic floating of watt-hour-meter rotors.

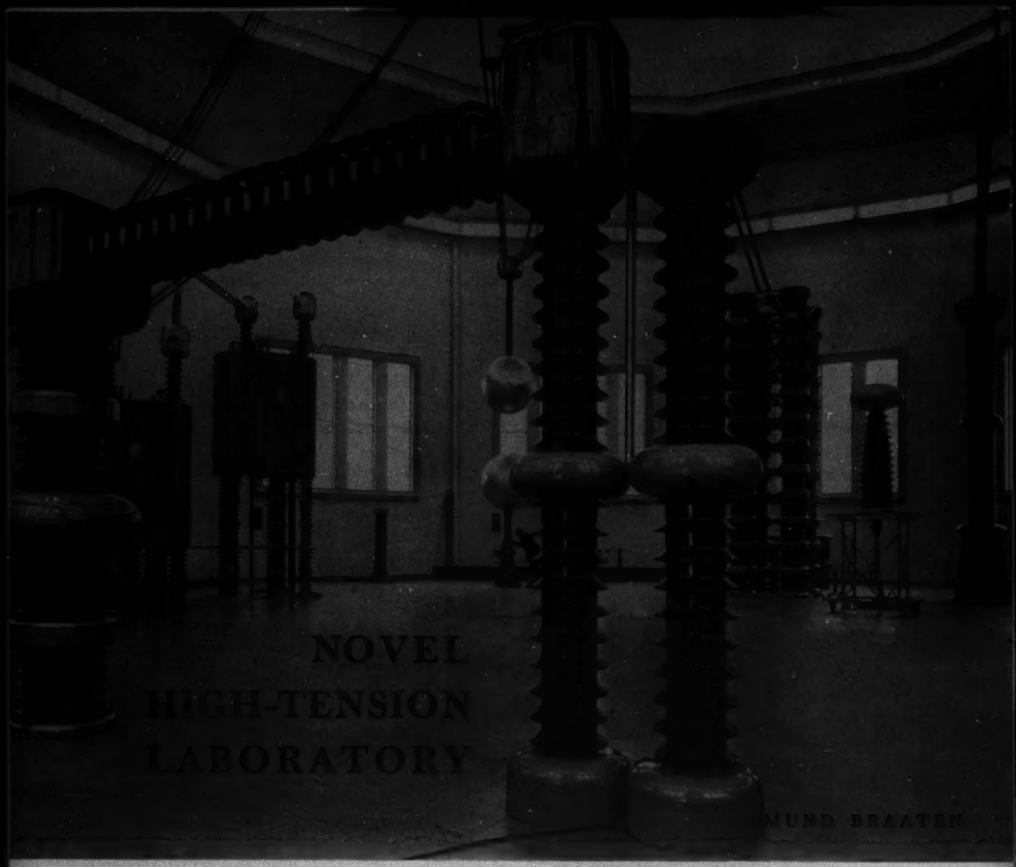
It is very much more difficult to estimate or even guess what revolutionary progress will be made in the electrical utility field. There is no difficulty at all in making up a long list of revolutionary ideas; however, it is not easy to evaluate which of these ideas may ultimately lead to a practical commercial development. In the category of things that may be done but which do not look promising for the near future—either due to the state of the art, inherent limitations, or the economic environment—are such items as solar energy converters for the production of commercial blocks of power, electronic refrigeration systems, household atomic power systems, and the use by utilities of fuel cells; that is, devices for the direct conversion of chemical to electric energy. Undoubtedly the most promising revolutionary development of the present time is the generation of electric power from atomic energy. This is a problem requiring a great deal of research and development, but it is one where there seems to be very little doubt about either the ultimate outcome or the economic justification.

Co-operation between equipment manufacturers and the utilities has brought the electrical industry to a position where it can look toward the future with unrivaled optimism. It is fortunate that this co-operation extends to the fundamental levels of research and development.

It is safe to predict that the electric equipment manufacturers will continue to allocate millions of dollars per year to research and development in areas of vital interest to the utility companies. This will be done in the competitive climate of the private enterprise system where the need for demonstrating the worth of what is done is an effective control to assure maximum results from research expenditures.

REFERENCES

1. *Electric Utility Industry in the United States, Statistical Bulletin for the Year 1953*, Edison Electric Institute, New York, N. Y., Table LIV, 1954, p. 620.
2. *Monthly Labor Review*, U. S. Dept. of Labor, Washington, D.C., September, 1954, p. 1071.
3. Methods of Operations Research (book), **P. M. Morse, G. E. Kimbal.** J. Wiley and Sons, New York, N. Y., 1950.
4. The Integrated Power System as the Basic Mechanism for Power Supply (book), **Phillip Sporn.** McGraw-Hill Book Company, Inc., New York, N. Y., 1950.
5. Observations on Operations Research, **M. L. Hurni.** *Journal*, Operations Research Society of America, Baltimore, Md., August 1954, pp. 234–48.



NOVEL HIGH-TENSION LABORATORY

AMUND BRAATEN

To avoid difficulties sometimes encountered in cable testing with high-voltage alternating current provided from cascade-connected transformers, a series circuit with variable inductances tuned to the cable's capacitance at 50 cycles is used in this European laboratory.

DEMAND for super-tension power-transmission cables in connection with the development of large water-power resources in Norway after World War II created the necessity for a modern high-tension laboratory for cable testing and development. For economic and defensive reasons power plants are preferably built underground, which necessitates the use of high-tension cables for linking the transformers with the outside switching plant.

Amund Braaten is managing director, Standard Telefon og Kabelfabrik A/S, International Telephone and Telegraph Corporation affiliate in Oslo, Norway.

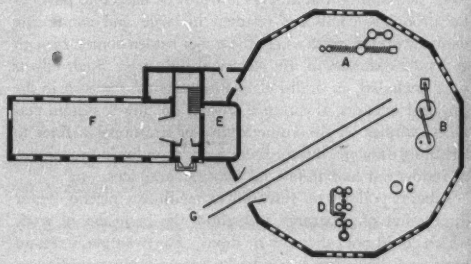


Fig. 1. Plan of the laboratory:

A—The 1,000,000-volt d-c test set; B—600,000-volt a-c reactor set; C—4.9-foot- (1.5-meter-) diameter spark gap. D—2,100,000-volt impulse generator; E—The control room (on the second floor); F—Physical laboratory, instrument shop, etc.; G—Railroad track

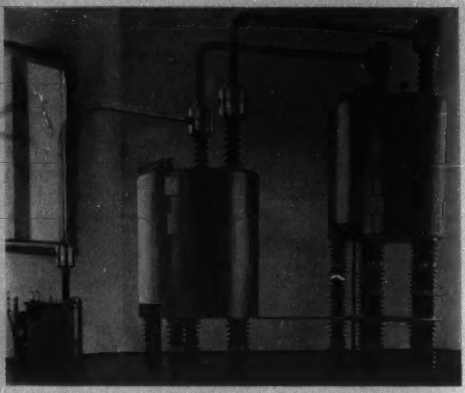


Fig. 2. A-c high-tension equipment. The feeding transformer is at the left. The two reactors step the voltage up 300 and 600 kv, respectively

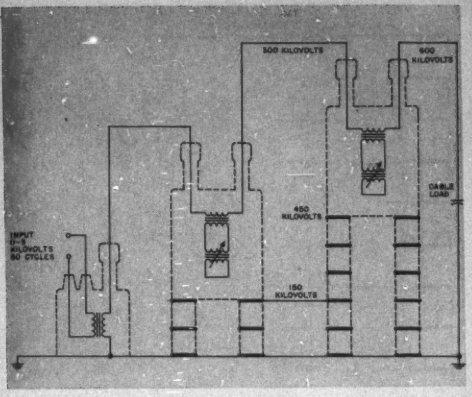


Fig. 3. Simplified diagram of the a-c plant. The two reactors are tuned by means of moving coils to resonate with the capacitive cable load at 50 cycles

Furthermore, there is a tendency to use cables instead of high-tension overhead lines in suburbs and built-up areas. There is also an increasing demand for high-voltage submarine cables for the electrification of coastal districts.

A plan of the high-tension laboratory building is given in Fig. 1, and the title picture shows a general view of the laboratory proper. The main building housing the high-tension equipment is 12-sided with a diameter of 98 feet (30 meters) and a floor-to-ceiling height of 46 feet (14 meters). The attached building has a floor space of 4,300 square feet (400 square meters) and accommodates offices, physical laboratories for investigating insulating materials, instrument-maker's shop, and the control room for operation of the high-tension equipment.

The electric installation consists of a 600-kv a-c plant, a 2,100-kv surge generator, and a 1,000-kv d-c test set.

The a-c high-tension equipment is shown in Fig. 2. It is capable of producing potentials up to 600 rms kv and has a load capacity of 2,400 kva for 30 minutes. It consists of two units that may be connected either in series or parallel.

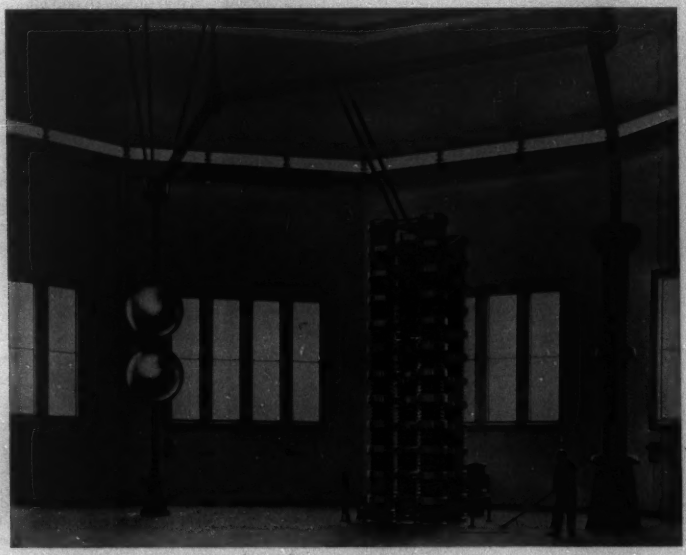


Fig. 4. The 2,100-kv surge generator. On the left is shown the spark gap and next the generator columns, and on the right the capacitive voltage divider

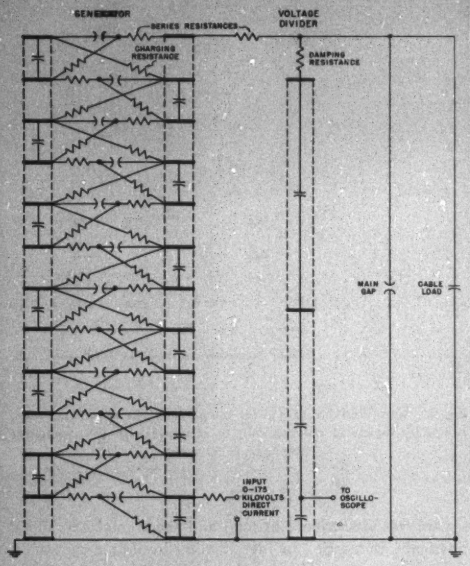


Fig. 5. Schematic diagram of surge generator. The capacitors in the generator are 0.16 microfarad each. The capacitors are charged in parallel. When the gaps in the column break down, the capacitors are discharged in series across the load. The maximum surge voltage is set by the carefully calibrated main gap

Space is reserved for the future addition of a third unit that will raise the voltage to 900 kv.

High-voltage alternating current for testing purposes is usually obtained by using cascade-connected transformers. With capacitive loads, as is usual in the cable industry, there is always a possibility of resonance between the cable and transformer reactances. If this should happen at one of the supply-frequency harmonics, the waveform of the terminal voltage will be distorted. Another disadvantage with the cascade principle is that the transformers do not divide the potential equally among themselves because of uneven distribution of the circuit reactance.

To avoid these difficulties, it was decided to substitute for the conventional transformers a series circuit, Fig. 3, having variable inductances tuned to resonate with the cable capacitance at 50 cycles per second. The series principle has the additional advantage that the short-circuit current at breakdown is reduced to a fraction of the load current. This is very important, as it avoids burning up the test specimens after breakdown. The reactors are continuously variable and are operated from the control desk.

Fig. 4 shows the surge generator, which is a conventional 2-column Marx circuit for charging capacitors in parallel and discharging them in series. The circuit is shown in Fig. 5. The highest charging potential is 175 kv per stage, giving the 12-stage generator a maximum discharge voltage of 2,100 kv. The energy per charge is 30 kw-seconds at full voltage. The generator has a low self inductance and is designed to give a standard surge with a 1-microsecond (μsec) front and a 50-μsec tail on short cable lengths. There is sufficient headroom to increase the generator voltage to 2,500 kv by adding two more stages.

For recording the surge, there is installed a 2-beam continuously pumped oscillograph with an accelerating potential of 45 kv, and having a writing speed of more than 6,000 miles (10,000 kilometers) per second, or 10 meters per microsecond. The impulses are transmitted to the oscillograph through a coaxial cable from the foot of a variable capacitive voltage divider (seen to the right in Fig. 4). The sweep can be observed on a fluorescent screen or it can be recorded directly on film.

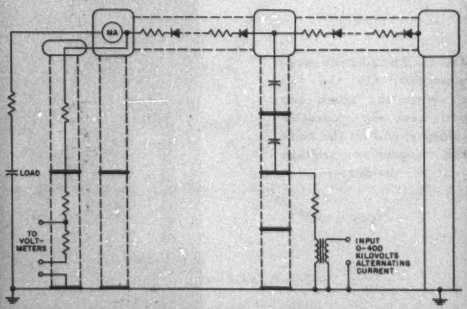


Fig 6 (left). The 1,000-kv d-c generator. Fig. 7 (above). Circuit of the d-c generator. The horizontal member has 64,000 selenium cells for rectification

Fig. 8. The glass-enclosed control room looks into the laboratory from the second-floor level. The high-speed oscillograph is at the extreme right and the various controls for testing are along the glass wall

Fig. 6 shows the d-c generator, which has a no-load potential of 1,000 kv and an output of 10 milliamperes. It is connected as a single Cockroft-Walton voltage-doubler circuit, Fig. 7. The horizontal member contains the rectifier consisting of 64,000 selenium cells. By means of external connecting links, the rectifier column can be broken into sections for parallel connection to give higher current capacities at lower voltages. The same arrangement also permits change of polarity. The generator is oil cooled, a circulating pump being mounted on the right-hand cooling column.

The control room is shown in Fig. 8 with the oscillograph at the right. For checking high voltages and for calibration purposes, a spark gap with 4.9-foot- (1.5-meter-) diameter spheres is used. The gap distance can be adjusted remotely from the control desk, which also contains an instrument indicating the gap opening. As is well known, the spark-over voltage can be determined with good accuracy when the sphere diameter and the gap opening are known and adjustments are made for atmospheric conditions. The spheres are also used for direct measurements of alternating voltages. In this case the voltage is read in kilovolts on a d-c instrument.

A system of bus bars is suspended from the ceiling for distribution of the potentials to the various parts of the test area. An extensive sectionalized grounding system is accessible at a number of points through wells in the floor. A railroad track is laid across the test area, making it possible to test heavy pieces.

To prevent disturbance to nearby radio receivers, especially when the surge generator is in operation, the laboratory walls and roof are electrostatically screened.

With potentials of the magnitude involved, it is often of interest to study corona discharges. These discharges emit very feeble light and must be observed in absolute darkness. For this purpose the main building is equipped with remote-controlled blackout curtains.

The high-tension testing equipment was delivered by Ferranti Limited, Manchester, England. The selenium elements were supplied by Standard Telephones and Cables, Limited of London, and the oscillograph by Trüb, Taüber and Company A/G of Zurich, Switzerland.

Standard Telefon og Kabelfabrik A/S is the only Norwegian factory making high-tension cables; the new laboratory will make it possible for the company to advance with the technical development of this field.

Transatlantic Telephone Cable

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The history of communication across the North Atlantic is traced briefly. The basic design features of the cable and repeater are discussed as well as the Key West–Havana cables and British shallow-water experience before a description of the complete system is given.

PLANS have been announced by the American Telephone and Telegraph Company and the British Post Office for the laying of the first transatlantic telephone cable system, scheduled for completion in 1956. Fifty-two long-life vacuum tube repeaters will be laid at depths up to 2 miles in each of two 1-way cables on a route approximately 2,000 nautical miles long connecting Newfoundland and Scotland. Newfoundland will be connected to Nova Scotia by a single cable containing 16 2-way repeaters.

The first commercial step in the march of transatlantic telephone communication dates back to 1927 when long-wave radio transmitting stations at Rocky Point, Long Island and Rugby, England went into operation. A year later short waves were put into regular use. Now, over the transatlantic route, there are 14 circuits between the United States and the United Kingdom and two between Canada and the United Kingdom.

Experience with short waves demonstrated their advantages of low cost, ease of providing direct access country to country, and flexibility in establishing and rearranging circuits. However, the disadvantages of unreliability (particularly on the North Atlantic route) and growing overpopulation of the short-wave spectrum soon led to studies of the feasibility of a North Atlantic submarine telephone cable.

EARLY AMERICAN WORK

IN 1919, in the laboratories of what was then the engineering department of the Western Electric Company (subsequently Bell Telephone Laboratories) a small group was organized under Dr. O. E. Buckley to study how to increase the transmission capacity of long deep-water cable.

By the late 1920's developments in submarine cable technology and in magnetic and insulating materials (the materials: permalloy, perminvar, and paragutta will be familiar as products of this era) reached a point where it became possible to visualize a single-circuit telephone cable to link the 1,800-nautical-mile distance between Newfoundland and Ireland. In fact, a proposal for a continuously loaded cable was formulated by the Bell System in 1928 and discussed with the British Post Office.

MULTICHANNEL TRANSATLANTIC CABLE PROBLEMS

IN 1928, when the cable plan was first formulated, electronic techniques were well established in land wire practice but practical application to submarine systems required subsequent developments, including negative feedback technology and the pentode tube. By 1932, the rapidly developing electronic art created a feeling of confidence that a multichannel cable with built-in submerged repeaters powered from shore could be built.

Many unique problems remained to be solved. The repeaters, and the cable itself had to withstand the pressures of transatlantic depth and the shocks of laying and recovery. Power levels must be low enough to feed over the cable at safe potentials and finally, but not least, the life of vacuum tubes and all other elements of the repeater must be long enough (say 20 years) to make the system technically and economically sound.

BASIC DESIGN FEATURES OF THE CABLE AND REPEATER

EARLY laying experience led to the objective of making the repeater structurally, as nearly as possible, like the cable itself. Thus the repeater could pass readily over the drum and sheaves of the cable ship and be paid out slowly without slowing up or stopping the vessel.

The essential and critical element of the repeater is the vacuum tube. The tube finally adopted was a very conservatively designed suppressor-grid pentode. The essential details of this tube were finalized in 1941 and have not since been changed. It has a large cathode area, unusually low cathode temperature (630 C), low plate potential (60 volts), large internal spacing between elements, and is generally of rugged shockproof construction. Some of these tubes have been under continuous test for over 13 years. Eighteen have been in operation for 4 years on the Key West–Havana submarine cable. All indications are favorable for something better than a 20-year life expectancy for these tubes in North Atlantic service.

In addition to tubes, a repeater incorporates about 60 other elements including resistors, capacitors, inductors, etc. Like the tube, these elements must be rugged, reasonably small, and designed and built to avoid all possible risk of failure in service. The designs evolved were based on the Bell Laboratories' wide background of experience supplemented by extraordinary care in selecting material and testing components during and after production. Open

* Institution of Electrical Engineers.

Revised text of paper 55-230, "A Transatlantic Telephone Cable," recommended by the AIEE Committee on Wire Communications Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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and simple structures were used to avoid hidden errors, and personnel was selected and trained for skill, self-criticism, and pride of product.

In this way there was incorporated into the development of each component all the knowledge and integrity that American telephone practice and experience provided. Wire-wound resistors, for example, have been made for 50 years, and there are something like 50 million of them in service. This type of resistor was, therefore, chosen for the submerged repeater in preference to the deposited carbon resistor which is of more recent origin. Similar experience was drawn upon in the selection of designs of inductors and capacitors. This experience was supplemented wherever possible by accelerated life tests.

A case in point is the selection of paper for the capacitors. Large quantities of this paper are purchased annually for the manufacture of capacitors used in the general telephone plant; the paper is supplied in lots which are submitted to accelerated life tests. The lots which performed best in an interval of 6 months were made available to the Laboratories where every roll was reinspected, and only those showing the highest life were chosen for the capacitors.

The design of cable finally decided upon consists of a solid dielectric coaxial structure covered by the usual jute and armor for protection and strength. The central copper conductor is a composite structure with a solid core and spiralling tape surrounds. The return conductor is also a composite of abutting spiralling tapes covered with an overlapping tape for teredo protection. The layers of tape and armor are all applied with the same direction of lay. Paragutta was used as the dielectric in early designs but has been superseded by polyethylene, developed in England shortly before World War II, because of its superior electrical and mechanical characteristics.

KEY WEST–HAVANA CABLES

During World War II the American group concerned with the cable was reduced to the barest minimum, but at the end of the war it was decided to install on the Key West–Havana route a pair of cables of the design that had been evolved for transatlantic service.

This work culminated in May 1950 with the laying of two cables (115 and 125 nautical miles). The system includes six repeaters, five of which are on the ocean bottom at depths ranging from 20 fathoms to 950 fathoms. The sixth repeater is located in a cable vault on the shore near the Havana telephone office. These repeaters have been in operation, at the time of writing, for 4 years without failure and without indication of deterioration.

BRITISH SHALLOW-WATER EXPERIENCE

Many submarine telephone cables connect the United Kingdom to the continent of Europe. These are of a variety of types and lie in water which is nowhere deeper than 300 fathoms. British development of submerged repeaters did not start until 1938, but in 1943 a coaxial cable between Anglesey and the Isle of Man was equipped with a shallow-water repeater. In 1946 a repeater was inserted into a cable between Lowestoft and Borkum to provide direct telephone communication to the British Armed Forces in Germany. These were the first uses of submerged repeaters for telephone traffic anywhere in the world. In these two early applications, *go* and *return* speech channels were provided over a single cable and separated on a frequency basis, the repeater being arranged to amplify the channels transmitted by the high-frequency band only.

The Post Office next turned its attention to the development of submerged repeaters suitable for operation in tandem. It was decided that the repeaters should be designed for two-way transmission. High- and low-pass filters were to separate *go* and *return* channels at each repeater, feeding a common amplifier.

The system since evolved, which may include up to ten intermediate repeaters, appears adequate for all routes between the United Kingdom and Europe. It was first installed in 1950 and about 20 repeaters are in operation. Very similar 36-circuit systems have been in operation for 4 years between the Netherlands and Denmark.

These earlier projects, while profitable and affording valuable experience, did not lead directly to a design suitable for a transatlantic project, or for installation elsewhere at ocean depths. In 1950, after a series of experiments in the Bay of Biscay and elsewhere, the Post Office set up a committee to report on the future possibilities of repeatered telephone cables on the transatlantic route. In 1952 it was decided to engineer a new telephone cable of about 300 nautical miles between Scotland and Scandinavia as a prototype for a system suitable for water of greater depth. An innovation in submerged repeater circuit design is the use in each repeater of parallel connected amplifier units with two separate forward paths and a common feedback path. The tubes are of a long-life type developed in the Post Office Research Laboratories for submerged repeater applications. The cables and repeaters were laid in 1954.

The decision to use deep-water type repeaters for this system was an important step in building up a background of experience which will be utilized in the Newfoundland–Nova Scotia section of the transatlantic system.

DECISION ON TRANSATLANTIC PROJECT

Early in 1952 negotiations were once again opened between the American Telephone and Telegraph Company and the British Post Office. Two of the present authors* reported jointly on the status of submerged repeater development in the United States and in the United Kingdom after independent studies by engineers of the Company and of the Post Office.

At that time the American development had been completed in its basic features for several years. The tubes and other components, initially constructed or selected for reliability in service, had been under life observation since about 1940. Cable and repeater designs for a transatlantic project had been subject to stringent laboratory tests and had finally been given the practical trials, already referred to, on the Key West–Havana route. The authors concerned recommended that these designs should be used for the long link between Newfoundland and Scotland as proved reliability is an essential requirement in a pioneering and costly venture as difficult as a transatlantic telephone cable.

* Kelly and Radley

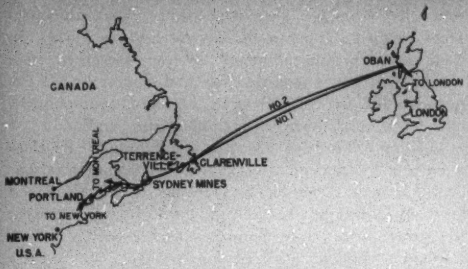


Fig. 1. Route across the Atlantic

There had not been the opportunity to subject the elements in the British development—particularly those which it was proposed to introduce as parts of a deep-water, as distinct from a shallow-water, system—to comparable tests. Nevertheless it was apparent that, if means for laying and recovering the large repeater housings in deep water without damage to the cable were later developed, the design would provide great flexibility in repeatered cable systems of the future. The authors, therefore, recommended that the British design should be used for the link between Newfoundland and Nova Scotia where the water is of moderate depth and offered the opportunity for observation of a design based on proved shallow-water techniques.

The Canadian Overseas Telecommunication Corporation was asked to join in the enterprise, because of its interest in overseas communication and of the desire that the project should also improve United Kingdom–Canada communication. Administrative and technical discussions took place on both sides of the Atlantic and agreements were arrived at and formalized in a contract signed on November 27, 1953. Ownership of the system will be vested in the American Telephone and Telegraph Company, the British Post Office, the Canadian Overseas Telecommunication Corporation, and the Eastern Telephone and Telegraph Company. The latter is a subsidiary of the American Telephone and Telegraph Company and will be concerned with the facilities within Canadian territorial limits.

GENERAL DESCRIPTION OF THE COMPLETE SYSTEM

Route. A map of the system is shown in Fig. 1. The route between Clarenville in Newfoundland and Oban in Scotland has been chosen so as to be well clear of existing telegraph cables, which lie to the southward, and also so as to avoid known "holes" in the sea bed.

Each of the cables between Clarenville and Oban will be approximately 1,950 nautical miles long and equipped with 52 repeaters. The greatest depth at which a repeater will lie will be approximately 2,300 fathoms (2.6 statute miles); most will be at depths between 1,200 and 2,000 fathoms.

The part of the system between Newfoundland and Nova Scotia falls into two parts; about 62 statute miles overland in Newfoundland and about 274 nautical miles in coastal waters at depths up to about 250 fathoms. The single cable will be equipped with 16 repeaters, 2 of these on land.

Circuit Capacity. The Newfoundland–United Kingdom cable will carry 36 channels in the frequency band 20 to 164 kc. The cable from Nova Scotia to Newfoundland will handle 60 carrier telephone circuits. One of the two 12-channel groups on this cable, not employed for transatlantic service, will be used to provide 12 circuits for "local" telephone service between Newfoundland and the rest of Canada; the other will be held spare for the present. The frequency allocation plan for the two sections is shown in Fig. 2 which also shows the location of test tones and order wire circuits.

The traffic operating terminals will be in London, New York, and Montreal. Twenty-nine telephone circuits will be put into service between London and New York and six telephone circuits into service between London and Montreal; part of the thirty-sixth channel will be used for London to Montreal telegraph circuits.

Over-all Performance. Since the transatlantic circuits are designed to connect extensive telephone networks on opposite sides of the ocean, they are being arranged to add as little extra loss and other forms of impairment as possible. Objectives for the circuits compare favorably with those specified for long-distance circuits wholly on land. Signaling over the cable circuits will be designed to allow coordination between the different national long-distance signaling systems at the ends.

CLARENVILLE–OBAN SECTION

Cable. The cable to be used on the transatlantic route will have a somewhat greater thickness of dielectric than that included in the make-up of the Key West–Havana cables. Manufacture of the cable will demand control of the dimensional tolerances to a greater degree of precision than has been attempted heretofore. This is because the large number of repeaters in circuit make it of great importance to maintain a fine balance between repeater gain and cable loss. Predetermination of the effects of temperature and pressure on cable attenuation will enable this fine balance to be obtained when the cable is at sea-bottom temperature and pressure. Impedance irregularities must also be avoided, since they affect the gain-frequency characteristics of the repeaters.

The make-up of the deep-sea cable is shown in Fig. 3. As customary, special cable armoring will be used near the shore ends.

Repeaters. The desirability of a flexible type of housing was referred to earlier. The structure of the repeater container is shown in Fig. 4. The whole structure is flexible, passing readily over the cable drum and bow sheave without requiring that the ship be stopped. To attain this flexibility, the repeater elements within the container are mounted inside a series of lucite (polymethylmethacrylate) cylinders, successive units being held together by a spring assembly to form an articulated system. Surrounding this series of lucite cylinders is a series of butt-ended steel rings. There are two layers of rings, the joints between successive rings in the two layers being staggered. Over the rings, and supported by them against collapse at sea-bottom pressure, there is an envelope in the form of a long tube of cop-

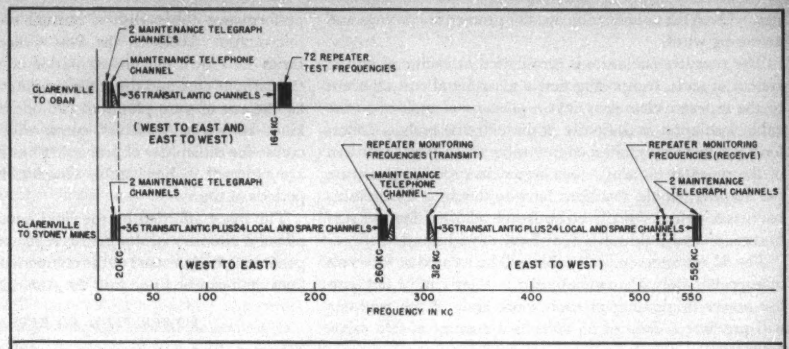
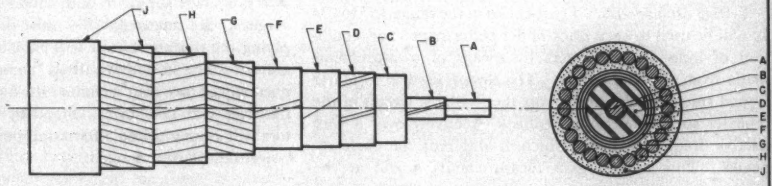
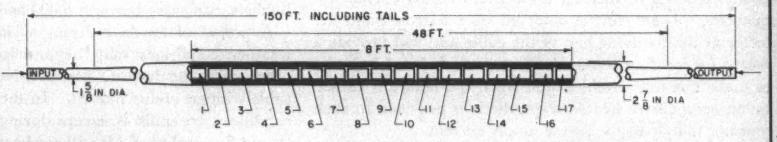


Fig. 2. Frequency allocation



A—Center conductor, Cu 0.1318 inch diameter; B—3 surround tapes, Cu 0.0145 inch; C—Polyethylene to 0.620 inch diameter; D—6 return tapes, Cu 0.016 inch; E—Teredo tape, Cu (overlapped) 0.003 inch; F—Telconax tape (gapped); G—1 serving cutched jute; H—24 armor wires, high tensile steel 0.086 inch diameter (each wire taped); J—2 servings impregnated jute

Fig. 3. Deep-sea cable: Type D—1.21-inch diameter



REPEATER UNIT SECTIONS

1 INPUT TERMINAL
2 INPUT BLOCKING CAPACITOR
3 GROUNDING CAPACITOR
4 CRYSTAL
5 INPUT NETWORK
6 VACUUM TUBE (FIRST STAGE)
7 FIRST INTERSTAGE NETWORK
8 VACUUM TUBE (SECOND STAGE)
9 SECOND INTERSTAGE NETWORK
10 VACUUM TUBE (THIRD STAGE)
11 OUTPUT NETWORK
12 BETA NETWORK (1)
13 BETA NETWORK (2)
14 GAS TUBE
15 DRYER
16 OUTPUT BLOCKING CAPACITOR
17 OUTPUT TERMINAL

ARMORED REPEATER

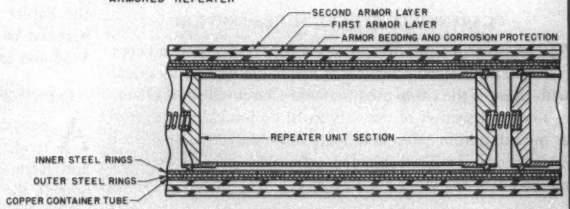
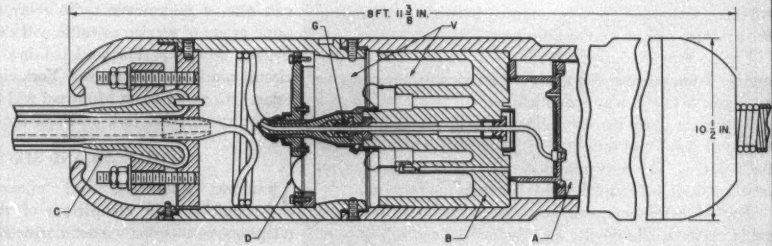


Fig. 4. Repeater structure: Clarenville–Oban section



A—Inner unit enclosing electric apparatus; B—Bulkhead (brazed in); C—Armor clamp; D—Flexible diaphragm enclosing vistac (V); G—Castellated gland

Fig. 5. Repeater housing: Clarenville – Sydney Mines section

per. Over the copper tube are the protective coatings and armoring wires.

The repeater enclosure is terminated at each end with a system of seals, comprising first a glass-metal seal adjacent to the repeater elements, next a plastic seal molded to the cable insulation and, finally at the extreme ends, a 7-foot-long seal formed within a copper tube which is an extension of the repeater housing. Sea water, in order to penetrate the housing, would therefore have to thread a long multi-barriered path. All of the seals are adapted for the sea-bottom pressures that they may have to withstand.

The 52 repeaters in each cable will be located at intervals of approximately 37 nautical miles. They will be fed with d-c power originating at each shore end. Each repeater will produce a drop of 55 volts at a current of 225 milli-amperes.

Testing Arrangements. Frequencies in the range 167 to 174 kc will be used to keep track of the performance and condition of individual repeaters by means of measurements made from the shore ends. The device used is a quartz crystal resonator shunted across the feedback circuit of the repeater so as to remove feedback effectively over a very narrow frequency band which is different for each repeater. Thus system gain measurements, made at the various crystal frequencies, provide a means for detecting, in each repeater separately, small changes in significant tube parameters which would not be disclosed with normal feedback. At the same time, the high gain at resonance creates a series of thermal noise peaks at the crystal frequencies. These can be observed by a narrow band detector at the receiving end of the cable and will provide a means for locating repeaters which have failed. In order to make this test possible, even when the failure is caused by an open-circuit heater, a gas diode is provided in each repeater to by-pass the power supply current.

CLARENVILLE–SYDNEY MINES SECTION

The structure and dimensions of the conductors and core of the submarine section of this cable will be identical with those of the cable used between Clarenville and Oban.

The land section of the cable will be basically the same as the submarine cable but, being more subject to electrical interference, it will be shielded with layers of soft iron tape, applied over the outer conductor.

Repeaters. The mechanical design of the repeaters which will be used in this section is shown in Fig. 5. The electric equipment is mounted in an inner-sealed cylinder filled with dry nitrogen. This is mounted between bulkheads in the pressure-resisting outer housing.

The 16 repeaters in this section will be located approximately 20 nautical miles apart. Electrically, they will be arranged to give 2-way amplification.

There are two 3-stage amplifier units in parallel between common input and output transformers with a single feedback path. The feedback network will maintain the repeater gain if one amplifier unit becomes inoperative.

The wide frequency range to be transmitted over the cable between Clarenville and Sydney Mines will only be made practicable by the use of comparatively modern high-performance tubes with a mutual conductance of 6,000 micromhos. Work in the Post Office Research Laboratories has shown that the formation of an interface between the cathode core and the emissive material can be prevented by the use of pure platinum cathode cores. Cores of this kind, known as "passive" cores, will be used; these increase the difficulties of processing but result in tubes which are expected to have stable characteristics over very long periods of time.

The space afforded by the rigid housing allows the complicated circuitry of the British repeaters and also makes it possible to design some of the components on more generous lines than can be fitted into the American flexible housings.

POWER FEED TO REPEATERS

Every effort will be made to ensure continuity of the d-c power supply to both cables so as to avoid voltage surges at the repeaters. To assist this, the alternator supplying the repeater power will have both a-c and d-c drive motors. The a-c drive from commercial supplies will normally be used, but on failure the d-c machine driven from batteries will take over. Stand-by diesel-driven generators will supply prime alternating power if the commercial power failure is prolonged.

CABLE-LAYING ARRANGEMENTS

All the cable will be laid by the cable ship *Monarch*. This ship, which was built for the British Post Office in 1945, has a gross tonnage of 8,056 and, with full oil bunkers, can carry between 5,000 and 6,000 tons of cable.

A period of 12 days during which continuously good weather conditions may be anticipated is necessary in order to lay the deep-sea part of a Newfoundland-Scotland cable without undue hazard. In the North Atlantic, such conditions are unlikely except during the period mid-May to mid-September and it will not be practicable to lay both the cables on the main crossing in one summer. It is planned to lay one of these cables during the summer of 1955 and to complete all cable-laying operations in 1956.

CONNECTION TO INLAND TELEPHONE NETWORKS

A description of the systems which will be used to extend the transatlantic circuits from Oban to London and from Sydney Mines to New York and Montreal is outside the scope of this article. Briefly, the transatlantic cable system will be extended by carrier cable from Oban to London, at which point it can be switched to the continent of Europe via existing cable circuits. On the American side, a microwave radio relay system providing the same grade of service as cable will extend the system from Sydney Mines to Portland, Maine. From Portland the circuit can be carried to New York either by cable or radio relay. Connection to Montreal will be effected at a point on the radio relay link north of the U. S. border.

CONCLUSION AND SPECULATION

Barring unforeseen and unexpected delays, 1956 should see the completion of the first transatlantic telephone connection via submarine cable. With the completion of this project, telephone service between the two

continents should enter into a new era marked by improved quality of service and reliability, and a capacity for growth no longer restricted by the limited capacity of the radio spectrum. The advantages of radio will remain, however: flexibility, the speed with which communications can be established and shifted from route to route, the feature of direct access from one country to another, relatively low cost, etc. These are not inconsiderable advantages and they augur for the continued importance of short-wave radio telephone services.

On the other hand, the new transatlantic cable will by no means represent all that could be done if full advantage were taken of contemporary techniques. The submarine cable art is a conservative one. As Dr. Buckley observed, the laying of a submarine cable, like any other activity on the high seas, must be planned with its unavoidable hazards in mind. Experience over 100 years has shown that in handling deep-water submarine cables on the high seas it is better to be safe than sorry.

But the consequences of this doctrine of caution are equally plain. The submerged repeaters in the 1956 deep-water cable section incorporate tubes whose proven design dates back to 1941, and with a mutual conductance of 1,000 micromhos. On the other hand, "conservative" postwar tubes provide mutual conductances in the range of 5,000 micromhos and tubes having a slightly better performance than this will be used in the cable system between Newfoundland and Nova Scotia under conditions where the consequences of tube failure will be minimized. The integrity of such postwar tubes under the severe and highly specialized conditions of installation and use encountered in submerged repeaters remains to be established. On the other hand, it is without question that with such new tubes, cable systems with still greater communication capacity can be realized.

Looking still further ahead, the transistor looms as a development which has the potentialities for making possible long deep-water submarine cables with much greater communication capacity than can be realized with repeaters employing thermionic tubes. The voltage required by the tube sets an upper limit on the number of them that can be operated in tandem before the power supply results in voltages on the cable that are beyond the limits of safety. The much lower power drain of the transistor should overcome this obstacle and permit more repeaters to be used and wider frequency bands to be accommodated. Ruggedness, long life, and small size are added attractive features of the transistor which are of not inconsiderable importance to the future development of submarine cables.

A transatlantic submarine television cable is a long-range goal worthy of serious study and by no means to be dismissed as impractical of eventual attainment.

ACKNOWLEDGEMENTS

THE concept of a transatlantic telephone cable owes its origin to the inspiration of Dr. Buckley's early work. He laid the firm technical foundation for such a project. The subsequent developments here recorded have been the work of many engineers on both sides of the Atlantic; on the American side in the Bell Telephone Laboratories, the Western Electric Company, and the Simplex Wire and Cable Company; on the British side in the Post Office Research Laboratories, Standard Telephones and Cables Limited, and Submarine Cables Limited. Without this work the particular project described here would have been impossible.

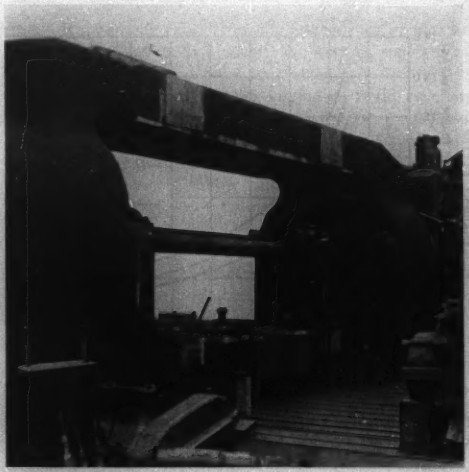
Direct-Extruded Aluminum-Sheathed Cable Press to Be Installed

Construction of the General Cable Corporation's new press for the production of direct-extruded aluminum-sheathed cables is announced by Irving T. Bennett, chairman of the board and chief executive officer, and J. R. MacDonald, president.

The new press by Schloemann of Dusseldorf, West Germany, will be delivered in mid 1955 and installed in the Perth Amboy, N. J., plant of General Cable Corporation. Representatives of Schloemann will supervise installation of the press and the start of its operation.

Many inquiries received by General Cable Corporation showed a desire to learn the advantages which direct-extruded aluminum-sheathed cables have over cables sheathed with lead or by other aluminum-sheathing methods.

It has also been said that aluminum sheathing is much less in cost per unit volume than conventional cable sheathing, it is much lighter in weight, and in addition to this it has much greater mechanical strength.



Voltage Gradients on High-Voltage Lines

G. E. ADAMS
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A KNOWLEDGE of the voltage gradient which exists at the surface of a transmission-line conductor is necessary in many instances. This knowledge is especially important in studies regarding corona losses and radio interference.

Also, the dimensions of laboratory models of transmission lines are often chosen so as to reproduce the voltage gradient which is to be encountered in practice. Hence, it is often necessary to calculate the conductor surface voltage gradients of different transmission lines.

Fig. 1 gives the gradient factor F_1 of the center conductor of a horizontal arrangement as a function of conductor diameter and spacing. Since the height above ground h as encountered in normal practice has very little effect upon the voltage gradient, the curves of Fig. 1 can be used for most practical purposes for all heights above ground h greater than about 30 feet. This gradient factor when multiplied by the rms line-to-line voltage expressed in kilovolts yields the gradient at the conductor surface in peak volts per centimeter.

The gradient factor of Fig. 1 was calculated on the basis of a smooth cylindrical conductor. However, many actual transmission line conductors are stranded and hence have an uneven surface. The voltage gradient varies along the surface of the conductor from zero at the points where the adjacent strands are in contact to a maximum at the points midway between.

Fig. 2 gives the stranding factor F_2 as a function of the number of strands in the outer layer. F_2 is the ratio of the maximum voltage gradient of a stranded conductor to the voltage gradient of a smooth conductor of the same outside diameter. Hence, the maximum gradient factor of a stranded conductor is given by

$$F = F_1 F_2$$

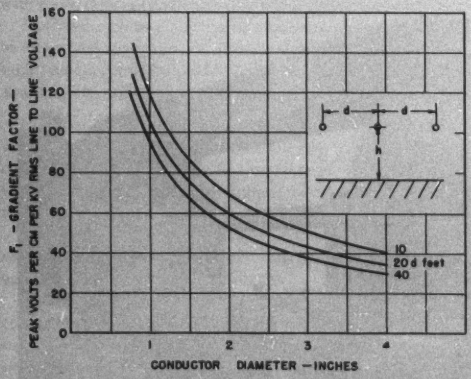

Fig. 1. Variation of gradient factor F_1 for the center conductor of a horizontal arrangement without ground wires, with conductor diameter and spacing for a height above ground of 60 feet

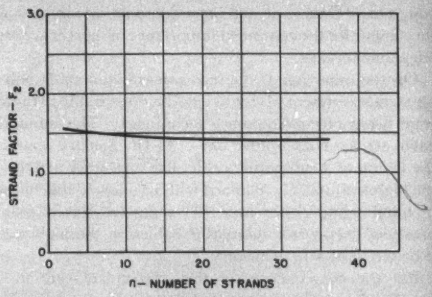

Fig. 2. Variation of the strand factor F_2 with the number of strands

The gradient factor of the center conductor of a vertical arrangement can also be determined from Fig. 1 to a very close approximation.

The gradient factors of the center conductors of the two vertical-arrangement 3-phase circuits of a double-circuit line are in general very nearly equal to the values given by Fig. 1 for the same conductor diameter and spacing. However, the gradient factors of the other phase conductors depend upon the choice of conductor phasing. This choice of conductor phasing can effect the voltage gradients of the outer conductors by as much as 10 per cent and may be very important in radio interference studies. If the exact gradient of each conductor is desired, a detailed analysis must be made.

Several conclusions can be stated for practical high-voltage transmission lines. The conductor diameter has the most significant effect upon the voltage gradient. An increase in diameter decreases the gradient. A reduction in conductor spacing increases the voltage gradient. Conductor height above ground and the presence of ground wires have very little effect upon the voltage gradient. The gradient on the ground wire will be small compared with that of the conductor even though the conductor diameter is several times larger than that of the ground wire. The maximum surface voltage gradient of a stranded conductor is approximately 40 per cent greater than that calculated on the basis of a smooth conductor of the same outside diameter.

Digest of paper 55-22, "Voltage Gradients on High-Voltage Transmission Lines," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Reliability of Insulation for Distribution Systems

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NONLEADED cables for underground systems began to be accepted in the mid 1930's, when the performance-type rubber compounds became available. This type of insulation had very good aging qualities compared with the previously available rubber compounds. These cables were covered with an impregnated cotton-braid jacket which had little insulating value but was intended mainly to provide mechanical protection to the cable while being pulled into the conduit.

Significant changes in nonleaded cable construction appeared after World War II. Most important was the introduction of a neoprene jacket. The toughness, resistance to abrasion and to tearing, relatively good resistance to oil, and lower degree of inflammability of neoprene, as compared with braid, make this cable definitely superior to the prewar nonleaded construction.

The two principal elements to be considered when comparing leaded with nonleaded cable systems are economics and service performance. It is the object of this digest to present a method for economic evaluation which can be generally useful, and to present data on the service performance of the two types of construction.

Cost comparisons between two types of cable are conveniently made in terms of expected life on the system and installed costs. For the purpose of this paper, the costs of different types of cable are compared on the basis of fixed annual charges, plus an annual charge to provide funds for replacement of the cable at the end of its life on the system. Fixed charges include interest on the investment, taxes (those which are based on investment), and such maintenance as is not related to deterioration of insulation. This will include such removals as arise from system rearrangements, city improvements, etc.

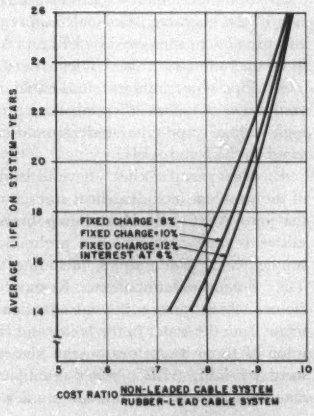

Fig. 1. Economic comparison of cable systems

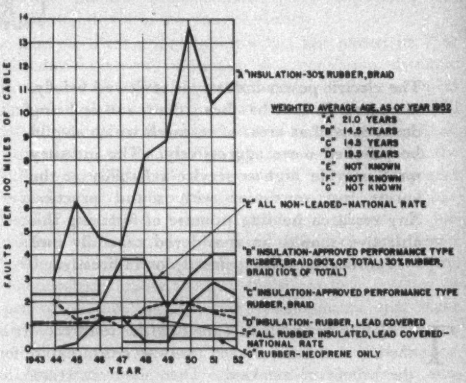
FAULTS PER 100 MILES OF CABLE
YEAR
1943 44 45 46 47 48 49 50 51 52
"A" INSULATION-30% RUBBER, BRAID
WEIGHTED AVERAGE AGE AS OF YEAR 1952
"A" 21.0 YEARS
"B" 14.5 YEARS
"C" 14.5 YEARS
"D" 19.5 YEARS
"E" NOT KNOWN
"F" NOT KNOWN
"G" NOT KNOWN
"E" ALL NON-LEADED-NATIONAL RATE
"B" INSULATION-APPROVED PERFORMANCE TYPE RUBBER, BRAID (90% OF TOTAL) 30% RUBBER, BRAID (10% OF TOTAL)
"C" INSULATION-APPROVED PERFORMANCE TYPE RUBBER, BRAID
"D" INSULATION-RUBBER, LEAD COVERED
"F" ALL RUBBER INSULATED, LEAD COVERED-NATIONAL RATE
"G" RUBBER-NEOPRENE ONLY

Fig. 2. Failure rates of various types and ages of low-voltage systems

Fig. 1 shows the average life in service a nonleaded system must have to justify the investment indicated relative to a leaded system with a 30-year life. It will be noted that the lower fixed charges favor the leaded system. Thus, if the installed cost of the nonleaded system is 80 per cent of that of the leaded system, then its life must be 17 years, $15^1/_2$ years, or $14^1/_2$ years with fixed charges of 8, 10 and 12 per cent, respectively, for equal cost. Interest at 6 per cent has been used in all calculations.

Data obtained on the experience of one large utility and from information available in national reports are shown on Fig. 2. The following conclusions are drawn:

1. Rubber-lead cables, showing no tendency to increase in failure rate up to 20 years service, may be expected to have a service life in the order of 30 years.
2. Performance-type rubber insulation, braid covered, shows no great increase in failure rate after $14^1/_2$ years and may be expected to have a service life well over 16 years and is economically justified.
3. Thirty-per-cent-rubber insulation, braid covered, installed about 1930 is now failing at a rapid rate and should be replaced.
4. Performance-type rubber with neoprene sheath, while too new to provide significant experience data, is undoubtedly longer lived than braid-covered cable, which is found to be economically justified and hence may be expected to offer appreciable economy over rubber-lead cable.

Digest of paper 54-338, "Economics and Comparison of Reliability of Leaded and Nonleaded Secondary Distribution Systems," recommended by the AIEE Committee on Insulating Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Published in AIEE Transactions, vol. 73, pt. III, 1954, pp 1478–81.

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Research in the Electric Power Industry

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The electric power industry is reviewed briefly, the research that has been done and is being done, as well as areas of research which should be pursued more aggressively. The industry must provide highest service reliability at the lowest cost consistent with sound practice. Any research holding promise of fostering this objective should be considered carefully and encouraged either directly or indirectly.

THERE is no question of the need for research. It is the key that has unlocked many secrets of nature for the benefit of mankind. There is every reason to believe that nature's storehouse has just begun to be tapped and that new developments and knowledge which lie ahead will dwarf the progress made to date. Research will permit a steadily rising standard of living. It was research that created the electric power industry, and it is proper to examine what part the utility industry should take in an aggressive research program. Certain types of research have been and are being conducted by the utility industry. These will be continued and expanded. There are other types that have no place in a prudently-managed utility company. These will be avoided. Between these two is a broad band of controversial activity that must be considered carefully.

MANY KINDS OF RESEARCH

THE English language is woefully inadequate to convey a common understanding of a simple statement. Psychologists say that a word or phrase will bring various associated ideas to the mind of the hearer. The simple word "blue" may be associated with the sky by one person, with someone's eyes by another, and with a deep placid pool by another. What does "research" mean to you? Does it bring to mind a white-frocked chemist in a laboratory filled with test tubes, or a scientist working with various complex electronic equipment, or possibly a doctor using a microscope to examine samples of living tissue? Certainly all these are research, but there are many others. To have a meeting of minds, it is necessary to be more specific and delineate the areas with care.

Research is defined by Webster as a "careful or critical inquiry or examination in seeking facts or principles; diligent investigation in order to ascertain something." Starting with this broad definition, here are the author's definitions of "fundamental research," "basic research," and "applied research." Fundamental research is seeking knowledge of fundamental laws of nature—without regard to the usefulness of the knowledge. Basic research is taking the knowledge of natural laws and applying it for the benefit of mankind. Applied research is seeking ways to improve a product, reduce its cost, or broaden its usefulness.

Full text of paper 55-145, "Research in the Electric Power Industry," recommended by the AIEE Committee on Research and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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RESEARCH BEING DONE BY INDUSTRY

CONSIDERED IN THE LIGHT of these definitions, there is a very substantial amount of research carried on by the electrical utility industry. Much of this might have been carried on by industrial concerns or by universities, but was initiated by utilities before other groups became interested. Much should have been included in the category of research, but was not so-classed. This includes work in the technical and scientific areas and frequently extends well beyond the scope of work usually associated with this industry.

A few of the research projects now active, or completed within the past few years, are listed. This partial list indicates the variety of problems being investigated by research supported either fully or partially by the electric power utilities.

1. Research on graphitization of steam piping. An investigation of the phenomenon of graphite migration and means of prevention, sponsored jointly by Edison Electric Institute (EEI) and the Association of Edison Illuminating Companies (AEIC).

2. Branch-circuit overcurrent protection. An investigation of the characteristics and requirements of branch-circuit protection, sponsored by EEI and AEIC and conducted in co-operation with the Underwriters' Laboratory.

3. Pipe-type underground-cable research. An investigation of factors affecting the rating and operation of high-voltage pipe-type underground-cable systems, sponsored by EEI and AEIC.

4. Heat pump studies. Several studies of various phases of the problem including heat storage media, sponsored by the joint AEIC-EEI Heat Pump Committee. The committee is now carrying on a preliminary investigation of supplemental heat sources, including solar heat.

5. Steam contamination. Research organized to study factors which govern the introduction of impurities into steam from the water in the boiler and the subsequent deposition of those impurities on the blades of turbines, sponsored by EEI, AEIC, boiler manufacturers, and turbine manufacturers. Fundamental studies in a little-known

brand of physical chemistry and the development of new measuring techniques were involved.

In addition to the above, active research has been carried on in the following fields, as well as in others not enumerated:

Electronic accounting machines for billing.
Artificial resuscitation.
Load characteristics.
Furnace-performance factors.
Atmospheric contamination.
High-temperature steam generation.
Welding.
Fly ash.

The Cable Engineering Section of AEIC has been very active in exploring many factors which affect cable rating, life, and operation. Excellent co-operation has been received from the cable-manufacturing companies. Preliminary work has been done on investigating the possibility of using extra-high-voltage cable. With presently available insulation it appears as if cable would have a very low load rating at 345 kv and could carry no load at 380 kv because of high dielectric loss. Research which pointed the way to a substantially lower dielectric loss in the cable insulation would improve the performance of existing cables and permit an extension to voltages in the 300 to 400 kv range.

In addition to these direct projects, there have been many carried on by various technical committees of industry organizations. This industry is unique in its policy of free interchange of information among its member companies. Troubles and errors are frankly discussed and all information made available to other companies having the same problems or equipment. A catastrophe may occur on one system; and within a matter of hours it is known and the highlights made available to other companies. Visitors arrive and are given full information. Later the troubles are fully discussed and analyzed at committee meetings. In addition, innovations, improved methods, better utilization of equipment, and economic simplification are discussed, and the complete details are made available to all interested. This atmosphere of frankness and mutual interest has created a committee organization of unusual effectiveness. It permits the entire industry to benefit from the pioneering of each member and allows the group to go forward with accurate scientific knowledge. Without this free and frank interchange, the progress to higher voltage, larger units, greater capacities, higher temperatures and pressures would have been much slower. The industry does not call this activity research, but certainly it is included if the aforementioned definition is considered.

PROGRESS THROUGH CO-OPERATION

Various needs must be weighed and evaluated. The utility industry needs a healthy and aggressive equipment manufacturing industry, and an aggressive utility industry is essential to a continuing improvement in living standards. Both need an alert and forward-looking group of technical educational institutions. These provide the lifeblood of both industries through the new talent that is trained. Without a virile and progressive educational program, there cannot be continued progress. Ways must be found to keep educational institutions healthy and solvent and to attract and hold outstanding teaching staffs. One way of doing this is to authorize research projects that will provide financial support and, equally important, will stimulate interest in the power industry.

The electrical utility industry has just passed its 75th birthday with every indication of a continuing dynamic growth ahead. There is a challenge for the best technical and managerial talent to carry on its traditions and fulfill its obligations. One of the reasons for this success is an extremely close relationship that has existed between the utility engineers and the engineers of the equipment manufacturers. Through the years, a co-operative partnership has grown between these two groups. It has resulted in unprecedented progress in new and better products with ever-increasing efficiency and reliability. The electrical utility industry could not have reached its present stature without the developments that have stemmed from this teamwork and the research and standardization that has been made possible. New designs, higher efficiency, greater economy, better reliability, simplicity of operation have all resulted from this partnership. All groups have shared in the benefits of this teamwork and any program of research must not interfere with it.

The equipment-manufacturing industry has provided research laboratory facilities and personnel to carry on an aggressive program of research. The fields of investigation are broad and include metallurgical, chemical, electrical, thermodynamic, and others. This has many advantages to the manufacturer and his customers. It makes available the results to a wide group and strengthens the sponsor. It also provides excellent facilities and technical talent to investigate a problem that may develop suddenly in connection with new products or new applications, and provides lower costs for the manufacturer that can be passed on, along with a better product, to the customer. Competition tends to increase the effectiveness of this arrangement and makes it far more productive than a single research center supported by many sponsors. There is nothing that provides a greater incentive than having a competitor get a temporary advantage through improvements in his product. It is a characteristic of the American buyers that quality and performance are far more important than price.

This research program must not be upset. It is proper that certain types of research should be conducted by the manufacturer and not by the purchaser. The customer should not be expected to do the research to improve the product he is purchasing, although he should make sure the product is the best for the application he has in mind.

The industry today is producing a kilowatt-hour for less than half the fuel required 30 years ago. This has not been brought about by any one group, but through the combined efforts of manufacturers of all types of equipment and the willingness of the utility industry to pioneer by purchasing and operating this equipment. Many times there has been a small venture into unknown regions and sometimes it has been necessary to backtrack temporarily. The utility

industry has been willing to pay the costs of the necessary research and to take the risk of expensive changes. The field modifications made in co-operation with the manufacturer have made many contributions to progress and scientific knowledge. There appears no other feasible way of doing this type of research—a million-pound-per-hour boiler cannot be set up in a university laboratory for research purposes, and small-scale models do not yield typical results. This activity is not called research, but it should be. That is undoubtedly one of the things that could have been more widely publicized in the past.

There are many similar projects which must be undertaken on a full-scale field basis and the research work done after operation starts. Naturally there are many components that must be designed, analyzed, tested, and modified in the shop before fabrication, but the over-all operation of the device cannot be accurately determined from component information. The necessary field work and many modifications are fed back into the manufacturer's design group and used to improve future products. This type of research makes a substantial contribution to the knowledge of the art and to the welfare and prosperity of the utility business, but does not get included in the discussion of research activities.

Even though a great deal of research and promotional activity is being carried on by the utility industry and by individual electrical utility companies, there is certainly ample room for improvement and a substantial expansion in the amount of activity. Dynamic and continuing expansion in the industry suggests that an increase in the level of research activity would be appropriate. There are many cogent reasons why the industry should be providing a more progressive research program. One obvious reason is that inherently the utility industry must obtain a long life from its plant investment. Industrial concerns are able to write off equipment on a short term basis, but this is out of the question for major plant investments of utility companies. Any research activity that will contribute to longer useful life and lower annual cost is highly beneficial.

NEW SOURCES OF ENERGY

THERE IS A NEW SOURCE of energy coming to the front—atomic energy. More of the U. S. scientific talent is devoting itself to atomic energy for war and peace than has ever been devoted to a single project. The utility industry is vitally interested in this field and is actively conducting research in many directions. A large number of electrical utility companies are participating in one or more study groups investigating atomic energy in all its peacetime power-producing aspects. Chemical, metallurgical, thermodynamic, mechanical, and economic factors are weighed and investigated. This work is being done in the laboratories of universities, industrial concerns, and research foundations. The recent changes in the law will permit greater use for peaceful purposes. The utility industry is now well advanced in its knowledge in this field and fully expects to continue on to the installation of large-scale atomic-energy applications.

This immediately brings to mind an item that has recently received wide publicity and has caught the fancy of the public. The conversion of solar radiation to electric energy has been improved and widely heralded. How does this affect the utility industry? Some of the semiscientific writers have envisioned a solar converter on every housetop with unlimited power available for all household uses, including heating and cooling of the home. It can be said without fear of contradiction that with present knowledge, materials, and costs, this is only a dream. But as research adds to knowledge and provides new materials the dreams of the visionaries are often realized or exceeded. Certainly the utility industry must keep abreast of all new developments in this field.

There may be other new forms of energy or energy conversion that will appear in the future. When these are discovered through research, the electrical utility industry must keep abreast of the developments and be ready to use them to supplement the older forms of energy conversion. This may require a research program to apply the knowledge and make the energy commercially useful, but the industry should not embark on a program of fundamental research to discover such energy sources.

PROGRESS THROUGH DISSATISFACTION

THE PROGRESS that has been made in the past 50 years can be keynoted as due to "dissatisfaction." The customers are eternally dissatisfied with what they have and want something better—new cars, new clothes, new homes, new appliances, new entertainment, and new roads. The dissatisfaction of the American public has been aggressive and vocal and any concern that does not cater to it will fail. This dissatisfaction extends into the factories and utilities. Better machine tools, better quality control, and better working conditions are always being sought. The utilities are dissatisfied with the service they render, with the equipment they buy, with the engineers educated by the universities, with the cost of equipment, and the operating expenses. They are always seeking a better, more reliable, more economical device that will be simpler and safer to operate.

This dissatisfaction is healthy, provided there is always a striving for something better and not just for something different. Dr. Hobson and Dr. Lewis were dissatisfied with the amount of research that was being sponsored in universities by utilities and had justification for it.[1] Their article is a provocative and able statement of one of the important problems facing the electric power industry. Very little has been done through this channel and more, much more should be done. But it would be most unfortunate if this did not meet two requirements: first, it must be research which will help the utility industry to move forward, and, second, it must be the type of research that can be done properly and effectively by the universities. Dr. DuBridge discusses this subject and points out the advantages of research, the needs for research, but above all the importance of doing the proper kind of research—not merely gadgeteering for the sake of obtaining financial support.[2] Research in a university can make a substantial contribution to the understanding of natural laws and act as a stimulus to additional research by other groups. The author, too, is dissatisfied with the amount of

research the industry is doing, and is also dissatisfied with the reliability of service rendered and with the costs achieved. If such research will make a substantial improvement in the service reliability or a substantial reduction in its costs, then the problem of the university research groups would be to find facilities and staffs to keep up with the research projects thrust upon them.

Industries hiring technical men have indicated dissatisfaction with both the quantity and quality of the engineers being educated. The electric power industry urgently needs a steady flow of good engineers capable of growth and development. It is essential to stimulate the interest of the teaching staff, as well as the students, in the opportunities ahead in the power field. One of the easiest and most effective ways of doing this is to provide research projects that will yield financial support for the institution and for the staff, as well as mental stimulation for the staff and students. There are many advantages in such a program, the least of which is that it can be self supporting and may pay substantial direct benefits. In addition, it provides financial support for improvement of physical facilities, helps to obtain and hold high-grade teaching staffs that could not be held otherwise, provides a real interest on the part of the men who are training and advising students, and it will yield a more adequate flow of well-educated engineers interested in the power business. Such a plan would also provide a pool of consultants conversant with electric power industry conditions and available when unexpected problems arise. There have been many cases where consultation was needed but was unavailable or was unknown.

WIDE RANGE OF POWER INDUSTRY

In thinking of the power industry, many people include only the electrical utility industry. Brief consideration will show that this is only a part of it and that the field includes the equipment manufacturing industry, all large industries such as mass transportation, automotive manufacturing, mining, and much of the entertainment and communication fields. New techniques in the electrometallurgical field require tremendous amounts of power. The aluminum industry has some of the largest hydroelectric developments in the world. Television and radio require large blocks of power, and color television will increase this manyfold. The power requirements of the fabricating and manufacturing industry are increasing steeply with the need for higher product output with lower costs and fewer men. The large factories have extensive power-distribution systems built with the requirement that they must be flexible enough to meet future changes in manufacturing techniques and power requirements. When thought is given to the power industry, credit should be given for its full scope.

Co-operative teamwork between the power industry and the educators will provide handsome benefits to both parties. Research provides a medium through which this can be done. There is a broad mutual interest between the educational institutions, the manufacturers, the contractors, and the utilities. This mutual interest should provide a strong incentive to work out a solution to benefit all.

FUTURE OF INDUSTRY

A brief review of the forecasted growth in electric power use by many experts presents a challenge of the first magnitude. Even if it is assumed that the growth slows down and the load doubles each 15 years there will be eight times the load by the year 2000. The efficient supply to customers at that time will require new knowledge in the fields of generation, transmission, distribution, utilization, accounting, and record keeping. Some of these problems are common to other industries, but some are unique with the public utility industry. The sooner this knowledge is available, the more healthy will be the growth.

Research by the electric utility industry is essential and a way must be found to strengthen and expand the research being supported by the industry. A tremendous job lies ahead even if forecasts of future growth are only partially fulfilled. Every tool must be utilized to assure that this job is done well. Research wisely-conceived and properly channelled is a tool that will assist in this sound growth and help assure that capable technical personnel is available to the industry.

REFERENCES

1. Research for and by the Electric Power Industry, **J. E. Hobson, W. A. Lewis.** *Electrical Engineering*, June 1954, p. 516.

2. The Goals of University Research, **L. A. DuBridge.** *Electrical Engineering*, September 1954, p. 790.

Temperature Measurements

Iridium, one of the world's rarest metals, is used as the heating element in a laboratory furnace that has enabled General Electric Company engineers to calibrate thermocouples for measurement of temperatures in jet engine combustion chambers. As in conventional laboratory furnaces, powdered aluminum oxide is used as insulation. Only about 500 watts is needed to produce the equivalent of jet engine temperatures from a 6-inch iridium coil. Chief advantages of using the iridium element are ease of control and use of an air atmosphere. The company's laboratory undertook the pioneer calibration work for its aircraft gas turbine development department in Evendale, Ohio.

Harry Alonzo Winne—John Fritz Medalist for 1954

"for services to his country in war and peace through his distinguished leadership in the electrical industry"

The John Fritz Medal

W. M. PEIRCE

THE John Fritz Medal has been termed one of the highest awards in the engineering profession. The stature of such a long-established award stems from two sources. The first is the reputation and character of the man in whose honor it is named and the merited affection and esteem which led his friends to establish such a memorial to him.

John Fritz, whose memory is kept fresh by the annual presentation of this medal, was born on a farm near Philadelphia in 1822. Characteristically of the times, his schooling was meager, but a lively curiosity and an early interest in the simple machinery with which he came in contact started his process of self education. When he was 16, he was apprenticed to a blacksmith, and at 21 he started work in an iron mill, of which in due time he became superintendent.

At the middle of the century the steel industry in this country was confronted with the problem of adapting to our raw materials and practices the Bessemer and open-hearth processes as developed in Europe. John Fritz was a major contributor to the solution of these problems and, as he pursued his career as general manager and chief engineer of Bethlehem Steel Corporation from 1860 until his retirement in 1892 at the age of 70, "Uncle John" earned the title of "father of the modern iron and steel industry."

John Fritz was a member of the American Society of Civil Engineers, President of the American Institute of Mining and Metallurgical Engineers in 1894, and President of The American Society of Mechanical Engineers in 1895 and 1896. Also, he was a member of the British Iron and Steel Institute. His distinguished career made him the recipient of many degrees and other honors.

On the occasion of his 80th birthday, a dinner was given in his honor and, as an outgrowth of this, the John Fritz Medal was established and endowed by gifts from his friends. A few years ago a substantial gift from Bethlehem Steel increased the principal to an amount sufficient to provide the medal annually and to periodically publish the collected biographies of the medal recipients in book form.

The basis for the award is "notable scientific or industrial achievement without restriction on account of nationality or sex." The fund is administrated by the United Engineering Trustees and four members of each of the Founder Societies constitute the Committee of Award.

The second source from which the prestige of such a medal as this stems is the lengthening list of renowned medalists. This is especially true of the John Fritz Medal, among the recipients of which are numbered men who have made many of the greatest contributions to science and industry during this century. In the perusal of the biographical sketches of these men, such as the one before you today, one will find himself among the epics of American science and industry of our times. To this saga we add the 51st chapter today.

Full text of the presentation and acceptance addresses given at the John Fritz Medal ceremonies during the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955.

W. M. Peirce, member of the John Fritz Medal board and past-president of the American Institute of Mining and Metallurgical Engineers, is with the New Jersey Zinc Company, New York, N. Y.

The John Fritz Medalist

C. H. LANG
ASSOCIATE MEMBER AIEE

AUTHOR, engineer, salesman, administrator, industry leader, government advisor, inventor, manpower developer, scientist, educator, humanitarian, American—Harry Alonzo Winne has contributed a thousandfold to

C. H. Lang is vice-president of public relations, General Electric Company, New York, N. Y.

the constructive advancement of the electrical industry and the nation as a whole.

Harry Winne is a painstaking technician and forward-looking engineer who tempers his technical ability with sound business judgment. He is a religiously honest man possessed of a humility such as few men of his accomplishments have.

Mr. Winne is a progressive industrial statesman who has devoted his life to the advancement of the electrical industry. He is noted not only for specific meritorious achievement during his long professional career, but more particularly for his leadership in directing broad engineering efforts within the General Electric Company, in industry over-all, and among men of science throughout the world.

Born in historic Cherry Valley, N. Y., October 28, 1888, he received his engineering degree at Syracuse University, graduating as head of his class in 1910. He joined General Electric at Schenectady, N. Y., that same year as a student engineer on the test program.

From 1910 to 1930, Mr. Winne served in various engineering capacities; from 1930 to 1936 he was head of Steel Mill Engineering; from 1936 to 1937 he was manager of Steel Mill and Mining Sales; he was assistant to the vice-president in charge of engineering from 1937 to 1941, and in 1941 was named vice-president of engineering, apparatus department. From 1945 to 1953 he served as vice-president of engineering policy, and in 1953 served as vice-president on special assignment to General Electric's president, Ralph J. Cordiner. He retired at the end of 1953 under the company's pension plan after 43 years of service.

Mr. Winne's early work with electrical precipitation, design of electric furnaces, and pioneering contributions to steel mill electrification (he holds 13 patents) has been overshadowed in recent years as he has come to be recognized as one of the world's leading industrial authorities on atomic energy.

In the early 1920's Mr. Winne's assignments at General Electric included the design and application of electric equipment for the Cottrell process of electrical precipitation. In that connection he contributed extensively to the establishment of appropriate characteristics for the various electrical components of such installations. He also made various contributions to the design and operation of electric arc furnaces and electric equipment for electric furnaces.

He joined his company's steel mill section in 1922 and was in charge of steel mill engineering for General Electric from 1930 to 1936. In the usually thorough manner which characterizes Mr. Winne's approach, he rapidly became intimately familiar with the steel industry, learned its requirements, and richly contributed to its electrification. Some of his outstanding accomplishments in this field are:

1. Contributed largely to the development of electric drives for continuous hot strip mills (Weirton Steel-1926, Wheeling Steel-1928, etc.). These were pioneering installations, blazing the trail for almost 30 additional hot strip mills which revolutionized the American steel industry, reduced the cost of flat rolled steel, and set the pace for foreign steel producers.

2. Contributed to the development of many speed-regulating systems used in the steel industry.

3. Pioneered in the use of recirculating ventilating systems for steel mill motor rooms; the first installation of this type being made in 1929 on a 30-inch bar mill at the Bethlehem Steel Company.

4. Made intensive studies of power requirements of rolling mills and of methods to calculate them, and presented, in 1932, a classical paper on this subject before the Association of Iron and Steel Engineers. This was the first paper on this subject published in the United States and has contributed richly to the store of engineering knowledge.

The results of Mr. Winne's industrial engineering work and constructive service still are in evidence and remain the basis of sound electrification of steel mill operations today.

His 13 patents are evidence of his direct contributions to the practice of engineering. They bear on the art of applied engineering and deal with improvements in a field where the quality of products depends upon rapid precision-control of processing machinery.

CO-ORDINATES ENGINEERING PROJECTS

To the engineering world, Mr. Winne is probably best known for his work as vice-president in charge of apparatus engineering at General Electric and for his execution of his responsibility in co-ordinating all of the company's engineering activities. During his service in these administrative positions, many of General Electric's most significant engineering developments had the benefit of his guidance, demonstrated engineering ability, and keen judgment.

In the critical World War II years he led his associates in a program that may never be equalled. Central gunnery control for the *B-29* bomber, the automatic pilot, the turbo-supercharger, the turbine-electric drive that propels modern tankers and destroyer-escorts, jet engines for the world's fastest airplanes—virtually all of the most famous war products turned out by General Electric were developments of his department. As a member of the company's War Projects Committee, he saw the need for these developments, understood the role he should play, and in characteristic thoroughness went ahead unhesitatingly.

From 1945, when he was put in charge of engineering policy for the entire company, the technological advances in which he led his associates have covered virtually every known area of engineering theory and application.

One of his responsibilities, the general engineering laboratory, serves as a storehouse of advanced technical knowledge, skills, and techniques for all of the company's product departments. It renders a consulting service in solving design and manufacturing problems occurring both within and outside the company and has been the incubator of many new products and specialized devices that have contributed much to engineering progress in the last half-century. It also functions as a General Electric "bureau of standards" for precision work in such fields as electric current, magnetism, radiation, optics, sound, color, and vibration.

Mr. Winne spearheaded a drive to engineer thousands of General Electric products so as to conserve materials that

were in critical supply. Approximately 10-million pounds of strategic copper were freed for vital defense production during 1951 alone as the result of this work.

He helped to initiate new streamlined industrial drafting techniques in General Electric as one means of combating the skilled manpower shortage. An estimated $60,000 a year in materials and as much as 50 per cent of the time normally required to prepare drawings was the minimum indicated saving as a consequence of his farsighted efforts.

These and hundreds of other achievements have been conceived and developed at Harry Winne's direction. His consummate judgment, technical acuity, and progressive managerial insight have proved a forceful stimulant to engineering technology.

ATOMIC ENERGY PROGRAM

But it is not in the engineering field alone that the impact of his wisdom has been felt. To the contemporary scientific world, Mr. Winne is best known through his work in the field of atomic energy. This began during World War II with his responsibility for General Electric's part in the over-all nuclear program under General Leslie R. Groves. Many of his contributions to this critical effort still are cloaked in secrecy, but some of his work was portrayed in "The Beginning or the End," Metro-Goldwyn-Mayer's movie on the development of the atom bomb.

Immediately after the war, Mr. Winne was named chairman of General Electric's 3-man Nucleonics Projects Committee which supervised the company's far-flung atomic operations at Schenectady, N. Y.; Richland, Wash.; and other locations throughout the country.

In 1946, he was one of a 5-man board of consultants (along with Lilienthal, Barnard, Oppenheimer, and Thomas) appointed by Secretary of State James F. Byrnes, to prepare the State Department's "Report on the International Control of Atomic Energy." This report became the heart of "The United States Atomic Energy Proposals" placed before the United Nations on June 14, 1946, by Bernard Baruch.

Mr. Winne remained in supervisory charge of General Electric's extensive atomic program for several years after the war, and he continues to be recognized by government agencies and industry groups as a leading authority on the use of atomic energy for the generation of electric power.

Because of his eminent stature in this field, he still is called upon to participate in project and committee work and is currently a member of the Nuclear Energy Committee of The American Society of Mechanical Engineers.

The government continues to seek and utilize his long experience and widespread knowledge of atomic energy by continuing him as chairman of the Technical Advisory Panel on Atomic Energy, Department of Defense.

In addition to his many achievements in electrical science, Mr. Winne's active interest in the vital area of development of professional manpower is particularly pertinent. This is attested to by his trusteeships at Syracuse University, Rensselaer Polytechnic Institute, Green Mountain Junior College, and Albany Medical College.

He was named by the National Security Resources Board to serve on the Scientific Manpower Advisory Committee in December 1950, and in May of the following year was appointed a member of the Committee on Specialized Personnel of the Office of Defense Mobilization.

Mr. Winne's broad engineering appreciation, combined with a keen ability to recognize engineering talent in others, was an important factor in selecting personnel and in focusing effective teamwork on General Electric's great variety of projects of far-reaching significance.

He is a member of the American Society for Engineering Education, and manpower development continues to be one of his many business and personal interests. He is chairman of the Divisional Committee for Scientific Personnel and Education, National Science Foundation, and a member of the Advisory Committee on Government–University Relationships, National Science Foundation. The full measure of his counsel and advice in this area may never be known, but those who have worked with him are well aware of his leadership, mature judgment, and contribution to this subject.

His own educational background includes a bachelor of science degree from Syracuse University in 1910; an honorary doctor of science degree from the same school in 1947; and honorary engineering doctorates from Rensselaer Polytechnic Institute in 1947, Newark College of Engineering in 1949, and Rhode Island University in 1953. He is a member of Tau Beta Pi, honorary engineering fraternity.

In his innate modesty, Mr. Winne refers to himself as "just one of the team." Those who know him best, however, are unanimous in appraising his personal contributions and leadership in those areas with which he has come in contact as being without parallel in our time.

Business Week magazine on its cover of August 31, 1946, printed a picture of Winne with the caption, "For U.N., atomic energy control; for G. E., atomic energy development."

On the inside it read: "Harry A. Winne of the General Electric Company is the kind of executive who starts talking about a job by saying, "I'm just one of a team!" To go along with the caption on the cover of that week's issue of *Business Week*, he would undoubtedly have preferred to see the portraits of seven men.

"Two of the other six would be Dr. Zay Jeffries, G. E. vice-president and general manager of its chemical department (now retired), and Dr. C. G. Suits, G. E. vice-president and director of research. These are the others who are associated with him in the nuclear advisory board through which, beginning Sept. 1, General Electric began to operate a plant in the field of a new and world-shaking type of power (page 17).

"The remaining four men are named Lilienthal, Barnard, Oppenheimer, and Thomas. These are names that, with his, will go down in history on the signature lines of the U.S. State Dept.'s 'Report on the International Control of Atomic Power.' That report drawn up by the State Dept.'s five-man board of consultants, became the heart of the 'United States Atomic Energy Proposals,' placed before the United Nations on June 14, 1946, by Bernard M. Baruch.

"Winne's nomination as a timely symbol of America's

perilous and hopeful venture into a new world of power arises from his presence on both teams, one primarily concerned with avoiding the peril, the other with achieving the hope."

AUTHOR OF MANY ARTICLES

Because of his extensive engineering background and reputation as an authority in many fields, Mr. Winne is the author of scores of technical articles and papers. A sampling of some of the best-known titles is given here:

1918, Spot Welding Applications in Ship Construction; 1919, A Simple Electric Water Heater for the Utilization of Surplus Hydro-Electric Power; 1921, The Electric Furnace as a Central Station Load; 1921, The Cottrell Process of Electrical Precipitation; 1926, Application of Synchronous Motors to Steel Mill Main Roll Drives; 1927, the Application of Synchronous Motors in Steel Mills; 1927, The Application of Direct-Current Motors to Main Roll Drives; 1931, 1930 Developments in Electric Equipment for Steel Mills; 1931, Electric Equipment for Steel Mills; 1932, Synchronous Ties; 1932, Electric Equipment for Wheeling's Wide Strip Mill; 1932, Determination of Motor Capacity for Main Roll Drives; 1934, Discussion of A-C Arc-Welding Transformer and Circuit Characteristics; 1935, Industrial Heating; 1935, Electrical Aids to Precision Rolling Steel; 1935, Electrical Developments in Steel Mills; 1936, Electric Furnace Development; 1936, Electric Developments in the Steel Industry; 1942, The Engineer and the War; 1946, Some Engineering and Political Aspects of Atomic Energy; 1947, Power—Where Do We Go From Here?; 1947, Atomic Energy in Industry; 1949, Atomic Energy in Our Time; 1950, Meeting Tomorrow's Needs; and 1951, What's Ahead for Engineering Students.

A spokesman for engineering progress and a conservative prophet of the future, Winne said in 1945, "Gas-turbine aircraft engines of the future may produce as much as 10,000 horsepower, more than the combined power of the *B-29's* four engines. Research and engineering alone will determine the ultimate limit, however, and the horizons appear to be limitless." At speeds of 750 mph, today's jet engines produce about 20,000 hp.

Always foremost in any endeavor which would benefit his fellowman, Mr. Winne in December 1947 made this statement:

"America cannot afford to lose its technical superiority, but neither can Americans afford to shirk their moral responsibilities. Our engineers must learn to apply to our social problems the same kind of fundamental thinking, the same singleness of purpose which they use on technological problems."

Despite the demands of his position which entailed considerable traveling to keep abreast of General Electric's fast-growing 132 plants in 101 cities and 24 states, Mr. Winne has given liberally and freely through the years of his time and talents to all worth-while community activities. Community Chest campaigns, the Young Men's Christian Association which he serves as a trustee and director, the Young Women's Christian Association of which he is a trustee, and Schenectady's huge Ellis Hospital, which he serves as president of the board of managers, have sought and cherished his wise counsel and warm personality.

The time which he has not given to his occupation and to philanthropic efforts has been devoted to raising a son and daughter and to improving the farm-home where he lives on a high hill overlooking the beautiful Mohawk Valley at Rexford, N. Y., a short distance outside Schenectady.

Mr. Winne married Dorothy Louise Hodges of Saratoga Springs, N. Y., at Saratoga in 1918. Their daughter, Miss Barbara Jean Winne, is in social work in Cleveland, Ohio, and their son, David H. Winne, is a General Electric engineer at Schenectady.

His friends attest to his generosity in sharing his farm for victory gardens during war days and the deep tan which he develops in early spring is evidence of the hours which he spends on the open land of his farm.

Retirement after more than 43 years with General Electric did not mean the end of an active business career but merely a diversification. The American Gas and Electric Company elected him to its board of directors and the Fiduciary Trust Company of New York did likewise.

In addition to honors conferred by educational institutions, Mr. Winne has won top engineering awards. The James J. McGraw Award for Electrical Men—Manufacturers Medal was presented in 1953 and a few months later the National Society of Professional Engineers Award for 1954 was conferred upon him.

Cherry Valley, founded in 1738 as the western frontier and scene of what is declared to be the most savage massacre in the American revolution in 1778, on July 10, 1954, paid homage to its most distinguished son, Harry Winne. The small village of 700 inhabitants had its population swelled for the day to about 10,000 and added a modern chapter to its history when an old cannon was fired by atomic energy to signal the opening of the day-long festivities. A cherry tree, flown from Richland, Wash., was planted in the village square because—despite its name taken 250 years ago from the abundance of cherry trees—it had not a single cherry tree in the village.

Dr. W. P. Tolley, chancellor of Syracuse University, Chester H. Lang, General Electric's vice-president of public relations, and Rear Admiral H. G. Rickover, one of the country's leading authorities on atomic energy and chief of the Naval Reactor branch of the U.S. Atomic Energy Commission, recounted the college life, and electrical-industry and atomic-energy contributions of Mr. Winne.

Mr. Winne is a Fellow of the American Institute of Electrical Engineers; an honorary member of The American Society of Mechanical Engineers; a member of the Newcomen Society, the American Society for Engineering Education, the New York State Society of Professional Engineers, and Tau Beta Pi.

His social affiliations include the Mohawk Club; Mohawk Golf Club; Edison Club of Schenectady; Cherry Valley, N. Y., Lodge No. 334, Free and Accepted Masons; and a membership in Theta Alpha.

What does a man with this unusual background think of the chance for peace in the future? He expressed it well in October 1951, when he said: "If Russia is to be deterred,

we must add depth to our productive capacity, for only the possibility of awful retaliation by a vastly strengthened American productive machine can assure peace."

The Response of the Medalist

HARRY A. WINNE
FELLOW AIEE

MY feelings at this moment are very mixed. Naturally, I am very proud to receive the John Fritz Medal, an honor that rightly is very highly regarded in the engineering field. But I have also a feeling of very deep humility, for I know, better than anyone else possibly can, that the engineering accomplishments which this presentation today recognizes were brought about not by me, but by the cooperative effort of the hundreds—yes, thousands—of my associates, most of whom are, or have been, part of the engineering organization of the General Electric Company in which I spent my active business life. I wish all of them could be here today and participate in this recognition, which so largely belongs to them.

Of course, I realize that a medal cannot be split into thousands of parts and distributed, and so some one person must be selected to receive the award, to in effect symbolize all of the real winners. I am happy and proud that I was so selected.

There can be no question that the engineers of this country, and of the world, do deserve recognition, not only by the engineering societies, but by every citizen. The engineers are a very important part of the team constituting industry—and I use the term industry in a very broad sense—which had added so much to our material well-being today. And the end is not yet!

As I look back over the 45 years since I left college, there is evident a great change for the better in the comfort of our homes and workplaces, in the amount of effort required to earn a living, in our transportation, in our communication, in our recreation facilities, and in fact in every material phase of our everyday life. In bringing these changes about, the engineer has played a leading and vital part. You may say that I am putting too much emphasis on the materialistic phases of our life, whereas social and cultural development is of such vital importance to our present and to our future. I agree fully on this importance. I can say only that the engineer has given us more leisure and time for social development. That we have not used this time to the best advantage is not the fault of the engineer alone.

The great increase in importance of the engineer during this period is indicated by the following figures from the recently issued fourth annual report of the National Science Foundation. In 1910 only 1 worker out of every 200 in the labor force of this country was technically trained. By 1950 the ratio had increased to 1 in every 60 persons. In other words, of all the people in the labor force, the percentage of those with technical training increased more than 3 times in 40 years. And the demand for technically educated personnel by industry, by educational institutions, and by government seems insatiable.

Now, what of the next 40 years. Shall we see as large an increase in the percentage of technologists in our work force? This I doubt. The curve of output from our technical and scientific schools has already begun to bend over very considerably.

Shall we see a comparable increase in our standard of living? I think, barring the cataclysm of an atomic war, we certainly shall. Even if the supply of technical personnel does not grow at a comparable rate, we have a tremendously broader background of technical knowledge to use, and on which to build. The excellence of the technical training offered our young people has improved over the years, and I hope will continue to do so.

In closing I wish to point out two matters which I feel are of great importance to our continuing technological progress, and which deserve immediate and careful consideration.

First, industry, government, and educational institutions must try to utilize the full ability of every technically trained person, so that he develops the maximum output of which he is capable. Among other things, he should have such assistants as he needs to perform tasks which are essential to his over-all objective, but which can be handled by persons less competent than he; he should have working conditions and surroundings which are conducive to maximum output; he should have adequate remuneration. Obviously, these remarks are applicable to everyone in the workforce, not alone to technical people.

Second, and perhaps more important, we must develop more and more-competent teachers. We must attract able people to the teaching profession by making it more rewarding than it is today, particularly financially, and especially in the secondary and elementary schools. Quoting again from the National Science Foundation report, "While high school enrollments go steadily upward, the proportion of college graduates who qualify to teach high school subjects continues to decrease."

The training of an engineer or scientist does not begin when he enters college. It certainly starts as early as his first years in high school, and perhaps earlier. If we are to have able engineers and scientists we must have competent science and mathematics teachers in the secondary schools. This is a matter which concerns all citizens. It deserves your emphasis in your community! This is one phase of technical education about which each of us can do something.

One last word—in our efforts to develop engineers and scientists, we must not forget that many other professions and fields of endeavor are extremely important to the overall welfare of our people, and these and their teachers also deserve our careful attention. A judicious balance in long-term emphasis on the various phases of our culture is essential to our happiness.

Harry A. Winne (retired) was vice-president, General Electric Company, Schenectady, N. Y.

Oliver Ellsworth Buckley
1954 Edison Medalist

"for his personal contributions to the science and art which have made possible a transatlantic telephone cable; for wide leadership of a great industrial laboratory; for outstanding services to the government of his country"

The Edison Medal

J. F. FAIRMAN
FELLOW AIEE

EVERY YEAR, during the Winter General Meeting of the Institute, the chairman of the Edison Medal Committee is called upon to inform some and to remind the others present at this ceremony that the Edison Medal is awarded "for meritorious achievement in electrical science or electrical engineering or the electrical arts" to "some one resident in the United States of America and its Dependencies, or of the Dominion of Canada."

The award of the Edison Medal signifies the recognition, sometimes belated, that there has been another breakthrough, another extension of the frontiers of our own field of electrical science, engineering, or arts, by another individual working with his hands and his brain.

The fact that the Edison Medal and a host of other awards are made annually is a symbol of the remarkable times in which we live. Man struggled for centuries before he mastered fire, more centuries until he learned to use the wheel, and it took him a long time to put the two together into a steam engine. Only a hundred years ago annual presentation of a medal with the stature of one of today's awards in the field of engineering would have been unthinkable.

Now, however, invention and discovery seem to tumble headlong over each other. It is as if man is ascending a staircase and growing all the time so that the treads appear progressively smaller to him and he is able to climb at an ever-accelerating rate. This is very good for man, but very difficult for the 21 individuals who make up the Edison Medal Committee. Theirs is the painful chore of objective evaluation and the selection of but one from many "meritorious achievements."

While this may mean difficulty for the committee, it is a good omen for our profession. The widespread originality, the high degree of achievement, the rapid betterment of the physical world at our command are healthy signs of growth. It is the engineer's task to translate dreams into reality, and our mission here is to recognize an outstanding example of this type of work.

Full presentation of the presentation and acceptance addresses at the Edison Medal ceremonies held during the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955.

J. F. Fairman, past-president of AIEE, is vice-president, Consolidated Edison Company of New York, Inc., New York, N. Y.

The Edison Medal for 1954 goes to Oliver Ellsworth Buckley "for his personal contributions to the science and art which have made possible a transatlantic telephone cable; for wide leadership of a great industrial laboratory; for outstanding services to the government of his country."

The Edison Medalist

O. B. BLACKWELL
FELLOW AIEE

A CAREFUL SELECTION of his ancestors has been called a man's most important act in building a successful life. But we are now told the environment which surrounds him in childhood is of equal importance in determining his character.

Oliver Ellsworth Buckley was fortunate both in inheritance and early environment. Born in a small town in Iowa, the center of an agricultural community, he was surrounded by people who were close to the soil. They needed no Disney film to appreciate the myriad forms of interdependent life which grow in and out of and over the soil. Against this rural background, books started to play an important part even before Buckley's birth. His Grandfather Buckley wisely put aside his plow on a New York farm, and so successfully sold reference books that Buckley's father had 2 years at Cornell University. Then an apprenticeship in a law firm laid the foundation for the father's success in life.

Buckley's mother, a daughter in a farm family who had emigrated from Scotland, taught the local country school at

O. B. Blackwell, Edison Medalist for 1950, retired, was with the American Telephone and Telegraph Company, New York, N. Y.

16 years of age. Their marriage produced a family of four—Oliver and three daughters. All attended college. All four became Phi Beta Kappas.

The father, active in law, real estate, insurance, and banking, was a leader in the community. The mother was a lady of such ability and charm that Oliver prepared and had printed a little book about her of pictures and text, so that her gracious memory could be more surely handed down in the family. The good supply of books in the home, the emphasis on education, the frequent family discussions of public affairs and philosophy, particularly the atmosphere of love and harmony in the family life, all joined well with inheritance in developing Buckley's character.

In delineating this character I would place first a spirit of co-operation at all times and in all things; next, an overpowering sense of duty and responsibility; then, a broad interest in the physical world and in the world of men and women. He could be critical in his judgment of men when it was necessary in handling a large organization; but never as critical of others as of himself, carefully weighing the ideas and opinions of others. Intellectually, he was both keenly analytical and creative, whether in physical investigation, developing of patents, engineering of systems, or the selection of men and building of organization, and with an excellent sense of humor.

Another matter can best be mentioned here, as it was in many ways a family affair. When Buckley could afford to marry, he naturally wished a family life like that of his childhood. A younger sister supplied the right lady when she introduced her college roommate. The resultant harmonious family life has been a constant sustaining help in meeting his many responsibilities.

Dr. Buckley's formal education led to a B.S. from Grinnell College, and a Ph.D. in physics from Cornell University. I know he rates highly some very early informal education such as independent reading about electricity, maintenance of a rural automatic telephone system, and even the care of five horses and time spent in the local blacksmith shop. Although not necessary, he showed his independence by earning part of his living at Grinnell, and all his expenses at Cornell, principally by acting as instructor. His scholarship led to membership in the honorary societies: Phi Beta Kappa, Sigma Xi, and Phi Kappa Phi.

Some men are awarded the Edison Medal for organizing, leading, and inspiring the technical work of others. Some for outstanding personal technical contributions. Dr. Buckley is the first Bell System man—I imagine there are few in any activity—whose work in each of these categories by itself merits the award.

One item of his citation says "outstanding services to the government of his country." In the first World War he helped organize the Research and Inspection Division of the Signal Corps in France, and then with the rank of Major directed its Research Section in Paris. In the second World War, as president of Bell Telephone Laboratories, he directed its own personnel of over 8,000 people and additional associated groups on work almost fully devoted to the war effort. Being both an oustanding scientist and the leader of a large organization of research and design, government departments and others frequently sought him for personal and committee work on technical matters requiring judgment. Among these, he was a member of a reviewing committee of the National Academy of Sciences in 1941, when proceeding on the atomic energy project was under consideration; also, a member of the Communications Division of the National Defense Research Committee, and chairman of the Television Section of its Guided Missiles Division. He received the Medal for Merit of the government for his activities.

In 1951, he was appointed by President Truman as chairman of the Science Advisory Committee of the Office of Defense Mobilization. He accepted this because of what he thought it should not do as well as what it should do.

The second item of the citation covers "wise leadership of a great industrial laboratory." Such leadership involved the innumerable problems common to all business projects of considerable size. It included wise general direction of its activities. Particularly it included the leadership of some thousands of highly educated, carefully selected, unusually talented technical people, and the development of the proper organization and atmosphere in which they could most effectively function.

The first item of the citation says "for his personal contributions to the science and art which have made possible a transatlantic telephone cable." On his return from the first World War, he was asked to consider the possibilities of improving submarine telegraph cable—a subject of interest to the federal government. He organized a carefully selected technical group and applied new methods and materials to the problem. It resulted in the New York-Azores loaded telegraph cable of some 4 times the message capacity of any previous cable, with little increase in cost.

The following work of Buckley and his organization on a transatlantic telephone cable was covered better than we can here in a joint paper by American and English authors given at the last Chicago convention. The paper appears in this publication of the AIEE.* The resulting transatlantic cable proposition now under way is the most audacious engineering project I have ever known. In this and other work, his inventions are covered by 43 patents.

Unfortunately, Dr. Buckley could not be at the Chicago convention or at the meeting of the Institution of Electrical Engineers in London, England, when the paper was given there. But on both occasions his voice was present in a recorded statement opening the discussion.

Recognition of Dr. Buckley's work includes the Government's Medal for Merit already mentioned; honorary doctorate degrees from Columbia University, Grinnell College, and the Case Institute of Technology; membership in the National Academy of Sciences, the American Philosophical Society, and Fellow of the American Academy of Arts and Sciences. The Bell Telephone Laboratories, on his retirement, endowed the Oliver E. Buckley Solid State Physics Prize. Administered wholly by the American Physical Society, $1,000 is awarded annually for 25 years for recent advances in solid state physics.

We have no time here to state his many services to the AIEE and Engineering Foundation, or to colleges and public schools, or to several other important organizations.

* See pp. 192-7.

For many years, Dr. Buckley had to meet his heavy responsibilities with less than normal sleep, which perhaps explains why his health since retirement has required less activity. But his idea of light activity includes about a dozen important items. He represents the engineering section of the National Academy of Sciences on the National Research Council, is one of the vice-presidents of the American Philosophical Society, a member of the Science Advisory Committee of the Office of Defense Mobilization, a member of the board of the Jackson Memorial Laboratory, and a member of the Army Ordnance Scientific Advisory Committee. Of the remaining items, I shall mention only the two which are particularly appropriate to a recipient of the Edison Medal. He is a member of the board of the Thomas Alva Edison Foundation, and a member of the National Inventors Council.

In closing may I make a brief very personal statement. I was an assistant for long years to each of the four recipients of this Medal who had responsibility for the establishment and development of the Bell Telephone Laboratories—Carty, Jewett, Gherardi, Buckley. Naturally, I think of Dr. Buckley with a background of my friendship with the three others who have passed on. Each added something precious to my experiences and memories. Only Dr. Buckley could have been quite so unmindful of his great accomplishments as to be really surprised when notified of the award of the Medal. No other has so large a place as he in the happiest of my memories. I count it a rare privilege to have a part today in the ceremonies honoring Oliver Ellsworth Buckley.

Some Observations Relating to Edison

O. E. BUCKLEY
FELLOW AIEE

IT is with great gratitude that I accept this medal which commemorates the name of one who brought light to shed on all. If some of its luster is reflected on the Bell Telephone Laboratories I can accept it the more happily, for it is to Bell Laboratories, where I served for many years, and to its members and its sponsors, that I owe all that is symbolized by the bestowal of this honor on me. I could speak at great length about the accomplishments of that organization, but I would rather take this occasion to make some observations about the man for whom the medal is named and about some of his works.

So great a reputation for miraculous achievement did Thomas A. Edison acquire that his name has become a legend. No medal or other memorial is needed to preserve his name; but we will all do well to recall his life and his achievements, for there is not a single one of us in this hall whose own life has not been profoundly affected by Edison, even though there may be only a few here who had the good fortune to know him while he was alive.

It was as an inventor that Edison achieved his great popular acclaim, but great inventor as he was, he was much more than that. He was a versatile engineer who saw all sides of an engineering problem. To him the incandescent lamp with its brilliantly conceived carbon filament was part of a system of illumination embodying a primary power source, means for efficient distribution of power, meters for measuring it, provisions for safety, and the multitude of components needed to make up the first electric illumination system for interior lighting. All of these had to be devised, developed, and built to achieve the ends he sought; so it was with many other projects that he created. Thus Edison was, among other things, a systems engineer. Indeed, he was in himself a complete research and development department. With all of his curiosity and enthusiasm, he kept his feet on the ground and had a sharp eye on the economic aspects of his undertakings.

Not all of his projects proved to be profitable but they were all well-considered investments of his money, time, and effort to uncover and apply new knowledge with useful and profitable ends in view. His methods in research were peculiarly his own and were very different from those of academic scientists, many of whom looked askance at his cut-and-try procedures. He was, it is true, an empiricist but a very intelligent one, well informed in theory but willing to try experiments just to see what would happen and without too much regard to their doing violence to accepted theoretical patterns. Intelligent empiricism has its place, though a more limited one, in applied research even today when we have so much better foundation of theory to guide us.

Edison's versatility was as amazing as his boundless energy. His curiosity and imagination led him into many fields, one of which was telephony. His contributions to that art were many. He was the first to use carbon contacts in a telephone transmitter. He invented a telephone repeater and a circuit in which to use it. The "Edison effect" which he discovered was basic to the amplifying vacuum tube developed later by others.

One of his most important contributions to telephony was an improvement in the granular carbon transmitter made about 10 years after telephones came into use. There is a story I have heard that representatives of the Telephone Company called on Edison to learn the details of his improved granular carbon. With some amusement he led them to his coal bin. He made it sound easy but the fact was that he had tested a tremendous variety of materials, including the then known semiconducting elements, the available rare earths, and a great variety of chemical compounds. Anthracite coal, ground up and roasted to drive off some of its gaseous content, proved to be the best. That he did a good job in this search is evidenced by the fact that today's greatly improved telephone transmitter still uses granular carbon made from anthracite coal. This story illustrates not only Edison's thoroughness and his recognition of the importance of materials, but also his delightful humor that pops up so frequently in reminiscences about him. In this character is his claim to the first use of "Hello!" as a telephone salutation, though according to his own

O. E. Buckley, retired, was president of Bell Telephone Laboratories, Inc., New York, N. Y.

Dr. Oliver E. Buckley, retired president, Bell Laboratories (third from left) receives the 1954 Edison Medal from AIEE President A. C. Monteith, also vice-president of Westinghouse Electric Corporation, Pittsburgh, Pa. Left to right are: J. R. Kerner, General Session chairman, Winter Meeting; O. B. Blackwell, 1950 Edison medalist; Buckley; Monteith; J. F. Fairman, chairman, Medal Award Committee; and A. J. Cooper, Meeting chairman

statement he never carried on a conversation over the telephone until 1915 when he talked from the San Francisco Exhibition to his associates in his laboratory in Orange, N. J.

With all the advances that have been made by great industrial laboratories since Edison's day, let no one think that the day of the inventor is done or that opportunity for invention is less. Indeed, with the great flood of new knowledge uncovered by fundamental research, the opportunity for those who have inventive talent is greater than ever.

Inventive talent is a somewhat rare product of heredity and environment. It is found among those of little formal education like Edison, as well as among those who have enjoyed the best of educational opportunity. Invention calls for a restless and inquiring mind and also practical common sense together with a desire to achieve useful ends. It calls, too, for a lot of hard work and persistence and a big store of practical knowledge. The "flash of genius" comes only to the fellow who is looking for it and can recognize the need for the new thing he has conceived. Even among highly selected research workers the productive inventors are relatively few.

With all of the opportunity for invention that now exists there is reason for concern lest the most not be made of it. The miraculous has become commonplace. High school courses in science and mathematics seem not to give the inspiration they once did. Life in the midst of highly perfected gadgetry does not give youngsters a feeling for technology and craftsmanship at the time of life when they are most readily inspired. These circumstances have led the Thomas Alva Edison Foundation to organize a joint effort of leaders in industry and education to take remedial steps in this situation and thus to contribute to the alleviation of the shortage of technical manpower. In this connection the Edison Foundation has also prepared, and made available for educational purposes, a number of inspiring booklets and pamphlets relating to Edison's activities and to the history of technology.

Another activity of the Edison Foundation is the preservation of Edison's laboratory, his library, his correspondence, and the thousand or more notebooks in which are recorded his original technical observations. These and other relics are on view at the Edison Museum in West Orange which attracts an increasing number of visitors every year and is well worth your while to see if you have not already been there.

There is more than sentiment to be fostered in the bestowal of the Edison medal and in the preservation of the relics of his activities. There is a lesson to be learned in the factors that surrounded and influenced the development of such prolific inventors as Edison, Bell, Westinghouse, and others of their kind, lest young potential inventors in our midst, now and in time to come, fail to realize this opportunity for achievement and public service that is open to them.

Equivalent Thermal Circuit for Nonventilated Motors

R. L. KOTNIK
ASSOCIATE MEMBER AIEE

ALTHOUGH heating is one of the chief limitations in the rating of induction machines, present methods of predicting heating leave much to be desired. Articles have been written on the subject of heating of very large motors and generators,[1,2] but relatively little appears to have been done toward developing accurate and comprehensive methods for calculating the heating of National Electrical Manufacturers Association (NEMA) frame size machines. Unfortunately, the methods developed for large machines are not well suited, as for smaller machines.

As a first logical step in solving this problem, an equivalent thermal circuit for the totally enclosed nonventilated induction motor based on the similarity of Ohm's Law of electrical conduction and Fourier's Law of heat conduction has been developed.

The basic equation for this circuit is

$$T = WR_t \qquad (1)$$

where R_t = the thermal resistance of the element, W = the rate of flow of heat energy through the element in watts, and T = the thermal potential causing the flow of heat energy.

When the flow of heat is a pure conduction phenomenon, then

$$R_t = (1/K_t)\,(L/A) \qquad (2)$$

where K_t = the thermal conductivity in watts per square inch, L = the length of the heat flow path in inches, and A = the area of the heat flow path in square inches.

When only conduction is involved, equations 1 and 2 can be used as given above; however, when heat is transferred by convection, the thermal resistance must be determined by an empirical formula derived from test data. Thermal potentials due to distributed losses, such as iron losses, are treated in this paper as "generated potentials" across "thermal generators."

Based on the above principles, the complete equivalent thermal circuit of the nonventilated motor was developed. Because this circuit appeared to be more complex than necessary, the circuit was simplified to that of Fig. 1.

This simplified circuit was evolved from the complete circuit by assuming that all of the stator copper losses are conducted to the frame through the stator core, that virtually all of the rotor losses are dissipated in the inner air and hence to the brackets, and that all of the friction and windage losses are windage losses. In this circuit, the core loss generator produces core iron losses, the tooth loss generator produces the tooth iron losses, the copper loss generator produces the stator winding losses, and the rotor generator produces the rotor copper losses and the windage losses. The generated potentials across the core and tooth loss generators are produced by the distributed iron losses. The generated potential across the copper loss generator represents the thermal potential between the center and the outside of the stator slot, and the difference in potential between the rotor and the inner air is represented by the potential across the rotor generator.

Obviously a reference temperature must be established to give meaning to the circuit. Since the frame temperature is the most logical reference temperature, a method described in the paper was developed for calculating it.

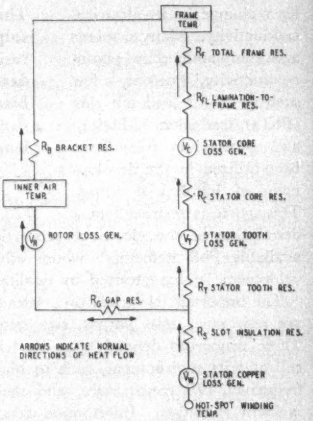

Fig. 1. Simplified thermal circuit of the totally enclosed nonventilated induction motor

Using this equivalent circuit to calculate the heating of a number of machines, it has been found that the average difference between the test and the calculated temperatures is about 4 per cent.

There is little doubt that the equivalent circuit concept is the best and most rational approach yet taken toward calculating heating of electric machinery. The particular circuit presented here appears to represent the complete thermal circuit of the nonventilated induction motor of the general size range of NEMA 180 to 505 frames quite well. The circuit is not complex nor are the calculations at all arduous. With some modification, the circuit could be extended to cover other types of enclosures. In addition, it could be modified to handle thermal transients.

Digest of paper 54-381, "An Equivalent Thermal Circuit for Nonventilated Induction Motors," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the Fall General Meeting, Chicago, Ill., October 11–15, 1954. Published in AIEE *Transactions*, vol. 73, pt. III, 1954 (Feb. 1955 section), pp. 1604–08.

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REFERENCES

1. Steady Flow of Heat in Large Turbine Generators, **R. C. Soderberg.** AIEE *Transactions*, vol. 50, 1931, pp. 782–802.

2. The Heat Paths in Electric Machinery, **Walker and Symons.** *Journal*, Institution of Electrical Engineers, London, England, vol. 48, 1912, pp. 674–746.

Photoconductive Detectors for Infrared Systems

ROY PAULSON

IT is apparent to those engaged in the fields of optics and infrared that a gap in scientific and technical continuity exists in the domain of photoconductivity between the basic work of the solid-state physicist and the empirical needs of the applied scientist. A collection of data concerning the important physical properties of the lead-sulphide(PbS) detector, and the suitable analytic expressions of its performance, would aid in bridging this gap. It is the purpose of this article to originate, collect, and organize such information.

A photoconductive detector is so named because it responds to incident radiation of an appropriate wavelength by a change in its electrical conductivity. Many elements and compounds show photoconductivity,[1] but only a few such as PbS,[2] lead telluride (PbTe),[3] lead selenide (PbSe),[4] and germanium (Ge) have been utilized in the development of infrared detectors. This article is restricted to a description of the electrical properties of commercially available PbS detectors* whose advanced state of development is characterized by qualitative reproducibility.

The important electrical properties of lead sulphide detectors are given, emphasizing resistance, noise, signal, and sensitivity. The functional dependence of these properties upon bias current, frequency, temperature, humidity, size, shape, background radiation, and wavelength of the incident radiation is included where possible.

The important electrical properties of infrared detectors are resistance, noise output, sign output, and sensitivity. These properties depend upon the characteristics of the cell and its environment, such as bias current, chopping frequency, cell temperature, and the wavelength of the incident radiation. Information concerning these characteristics is presented in the ensuing discussion as figures and graphs. Where possible, the data apply to "typical" PbS cells and are in a form which appears best suited to system design purposes. Application of these data must be made with caution because of the wide variations in the properties of a detector.

*Some of the main commercial suppliers of PbS cells in the United States are Eastman Kodak Company, Rochester, N. Y. (Ektron detector) and Continental Electric Company, Geneva, Ill. (Cetron detector).

PHYSICAL DESCRIPTION

MOST PbS cells appear either in the form of a vacuum-sealed envelope or a thin glass slide, depending upon whether they are made by evaporation or by chemical deposition. Both types of cells consist of conducting electrodes, usually made of gold or Aquadag and a sensitive surface of PbS.

The actual size of the detectors varies widely depending upon the sensitive area, the electrodes, and the size of envelope or slide. For rectangular films, the dimensions of sensitive surfaces vary from a few tenths of a millimeter to a few centimeters on a side, with a film thickness of the order of a few microns.

Several types of PbS cells are shown in Figs. 1*A* and 1*B*. The cells in Fig. 1*A* are in groups numbered from 1 to 4 corresponding to the manufacturer: 1. General Electric Company, 2. "Cetron" or Continental Electric Company, 3. British Thomson-Houston Company (English), and 4. Zeiss (German). All the cells of Fig. 1*B* are "Ektron" detectors made by Eastman Kodak Company.

PROPERTIES OF PbS DETECTORS

PHOTOCONDUCTIVE DETECTORS are usually used in a circuit similar to the one shown in Fig. 2. The electrical properties of PbS detectors are treated here in terms of the a-c equivalent circuit, also shown in Fig. 2. Under certain restrictions, the signal (S) and noise (N) of the equivalent circuit are the signal and noise output of the typical circuit. The necessary restrictions are:

1. C is chosen so that its impedance and noise are negligible compared with those of the cell at all frequencies of interest.
2. R_L is much larger than R.
3. The noise voltage generated in the load resistor R_L is

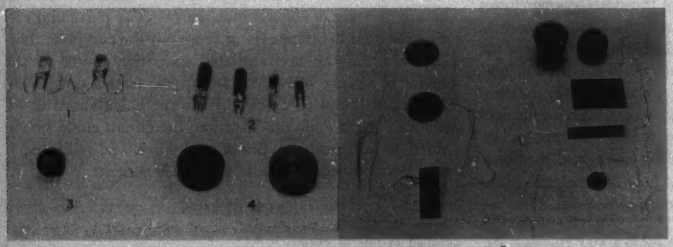

Fig. 1. Lead sulphide cells

Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954 and recommended for publication by the AIEE Subcommittee on Infrared Applications.

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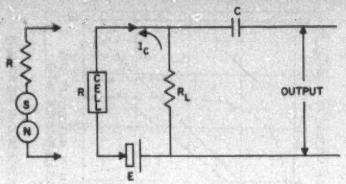
negligible. (This is true when rms noise of $R_L/N << R_L/R$.)

Resistance. The d-c resistances of PbS cells vary widely from cell to cell. For example, practical values for square films at room temperature will vary from 0.2 to 8 megohms. The cell resistance is dependent upon the cell's stoichiometric properties (lead to sulphur ratio) and upon impurities present in the PbS layer. Properties introduced into the cell by impurities and cell stoichiometry are very very difficult to control during the making of detectors; therefore, resistance variations arise. Although an extensive study of the aging properties of PbS detectors has not been made, several detectors have shown no noticeable changes in their resistance over a period of several years.



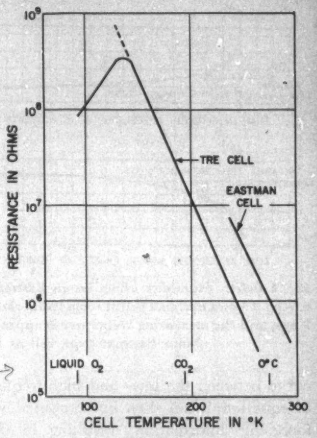


Fig. 2 (above). Typical PbS cell circuit and cell equivalent circuit.* In this circuit, R is the cell dark resistance, E is the bias battery voltage, I_C is the d-c bias current, R_L is the load resistance, C is the coupling capacitor, S is the signal generated in the cell by a change in resistance, and N is the total rms noise voltage generated in the cell. Fig. 3 (right). Temperature–resistance curves for PbS cells

Typical curves of the temperature–resistance relationship for two PbS cells† are shown in Fig. 3. Although these curves indicate that the resistance decreases monotonically, the *TRE* cell resistance shows an increase in resistance at very low temperatures. This low-temperature behavior is thought to be due to the detector "seeing" the ambient background radiations. It is expected that if the background were cooled, the resistance would follow the broken-line curve.

The detectors appear to have the same temperature dependence as that of bulk semiconductors, as expressed in the equation.[5] $R \simeq \text{Constant}\ (\exp E/KT)$, where R is the resistance, E is a constant related to the energy difference between electron bands, K is Boltzman's constant, and T is the absolute temperature.

Although PbS cells usually obey Ohm's Law at low cell currents, deviation would be expected to occur when the bias power applied is enough to cause heating of the sensitive film. It is also possible that local heating could destroy some of the "sensitive spots" in the film, thus causing permanent changes in the cell's characteristics.

A change in relative humidity, from 90 to 0 per cent, causes a resistance increase in Ektron detectors by a factor of 3. The effect on the detector of a change in humidity with respect to time is shown in Fig. 4. Short term effects occur within 15 seconds; however, longer term effects which do exist are not shown.

If the PbS films are homogeneous and of uniform thickness, their resistance per square unit area should be constant; for rectangular films, this resistance may be expressed by: $R = rL/W$, where R is the cell resistance, r is the resistance per square unit area, L is the length of the sensitive surface (electrode to electrode), and W is the width of the sensitive surface.

†The data for an Eastman cell are taken from information Eastman Kodak furnishes with their Ektron detectors. The data for the *TRE* cell were obtained from *TRE* memorandum, *L3/53 TSM*, (limited distribution).

Although the films are far from homogenous, as would be expected by their crystalline structure, the foregoing relation holds fairly well. Table I indicates that the resistance per square area is constant, and that, for large values of the ratio, the resistance is not proportional to the length-to-width ratio. Wide resistance variation of the cells is also shown in this table.

Noise. The noise output of PbS detectors is due to many causes which have been discussed in detail by others.[6] An experimental expression which appears to fit the data obtained for many PbS cells is

$$N \simeq \text{Constant}\left(\frac{I_c}{W}\right)\left(\frac{L}{W}\right)^k G(f) \ddagger \qquad (1)$$

where N is the rms noise output voltage of the cell, I_c is the d-c bias current, L is the length of the sensitive surface (electrode to electrode), W is the width of the sensitive surface, k is thought to be a constant of about 0.5, and $G(f)$ is the measuring frequency dependence of the noise.

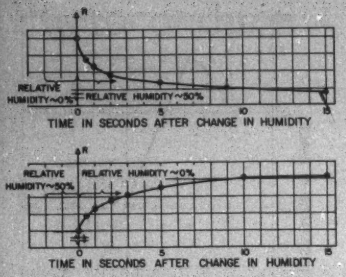
This expression applies when the bias current is high enough to make the current-dependent noise much larger than the Johnson noise of the detector. Typical noise output voltages range from a few tenths of a microvolt to a few microvolts for PbS cells at room temperature and normal operating currents, with a 4-cps measuring bandwidth.

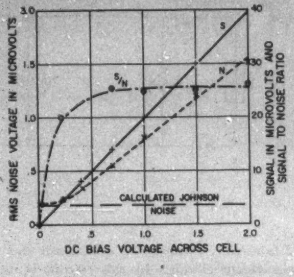
The noise variation with d-c bias current is shown in Fig. 5 for a typical PbS cell. It is seen that the noise is directly proportional to the cell bias current except for very low currents. At zero bias current, the noise is the Johnson noise of the detector.

Cell noise voltage is a function of the measuring frequency f as illustrated in Fig. 6. An $f^{-1/2}$ curve is also shown in Fig. 6, and a comparison of this with the cell noise curves indicates that, for constant bandwidth, the noise spectrum can be approximated by $f^{-1/2}$.

The bandwith dependence of the noise may also be calculated from Fig. 6. The noise power may be obtained for wide bandwidths from the area of the square of the

‡This equation applies to rectangular sensitive films only.





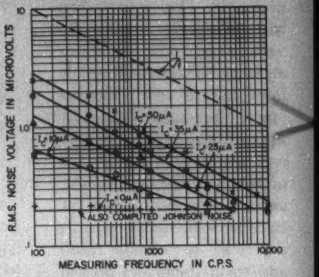


Fig. 4 (left). Humidity effect on an Eastman cell. Fig. 5 (center). Signal, noise, and signal-to-noise ratio versus bias current. A 0.5- by 0.5-mm Eastman cell at room temperature, with a cell resistance of 0.27 megohm was used. The noise bandwidth is approximately 7 cps, and the measuring frequency is approximately 90 cps. Fig. 6 (right). Frequency versus noise voltage. For this graph, a 2- by 2-mm Eastman-type cell at room temperature was used. The bandwidth was approximately 7 cps

curve between the low- and high-frequency cutoffs. $G(f)$ of equation 1 can then be computed with the aid of the foregoing information, resulting in $G(f) \simeq (lnf_H/f_L)^{1/2}$, where $G(f)$ is the frequency dependence of the noise, f_H is the high-frequency cutoff of the noise bandwidth, and f_L is the low-frequency cutoff of the noise bandwidth.

No information has been obtained on the noise as a function of cell temperature except that furnished for Ektron PbS detectors. These data indicated that for constant bias voltage, the noise varies slowly with temperature. No data are available on the humidity dependence of the noise.

In Table I the area dependence of the noise is shown for some PbS cells, and, although the data are widely spread, it indicates that the noise is independent of the cell area for constant current density. An attempt has been made to determine the shape or length-to-width dependence of the noise, (k in equation 1) but the data proved to be inconclusive except to indicate that k could be any value between zero and one.

Signal. The signal output of a PbS cell is the result of a change in conductivity of the detector. It should then be proportional to both the bias current and the resistance. Experimentally, for rectangular sensitive areas the signal may be approximated by

$$S \simeq \text{Constant} \cdot \Phi \, I_c \frac{L}{W} S(f) \cos\theta \qquad (2)$$

where S is the signal generated by the cell, Φ is the incident power density striking the film when uniformly illuminated, I_c is the d-c cell bias current, W is the width of the sensitive surface, L is the length of the sensitive surface, $S(f)$ is the chopping frequency dependence of the signal, and θ is the angle between the normal of the sensitive surface and the incident radiation.

Typical values of signal output range from a few tenths of a microvolt (signal = noise) to a few volts. The d-c cell bias current versus signal voltage is illustrated in Fig. 5, which indicates that the signal is proportional to the cell current.

Measurements of the signal dependence of the angle of incidence of the radiation are shown in Fig. 7. There appears to be no deviation from the cosine curve for angles up to 80°.

The frequency dependence of the signal for a typical

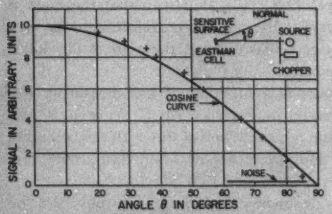
Table I. Size and Shape Dependence of Signal, Noise, and Resistance

Eastman-Type Rectangular Cells at Room Temperature

Length / Width	Length, Mm.	No. Cells	Signal in Microvolts§ Min.	Signal in Microvolts§ Aver.	Signal in Microvolts§ Max.	RMS Noise in Microvolts‖ Min.	RMS Noise in Microvolts‖ Aver.	RMS Noise in Microvolts‖ Max.	Resistance in Megohms Min.	Resistance in Megohms Aver.	Resistance in Megohms Min.
1 / 0.5	0.5	5	140	164	190	0.88	0.99	1.2	0.41	0.46	0.49
1 / 1.0	1.0	9	120	175	210	1.2	1.6	2.1	0.37	0.47	0.58
1 / 4.0	4.0	16	74	106	200	0.46	1.1	1.6	0.21	0.42	0.60
1 / 10.0	10.0	13	84	107	135	0.60	0.83	1.2	0.21	0.40	0.66
2 / 10.0	10.0	2	230	290	350	0.61	0.72	0.83	0.82	0.87	0.92
2 / 20.0	20.0	2	360	375	390	0.99	0.99	0.99	1.4	1.4	1.4
4 / 20.0	20.0	2	360	370	380	0.72	0.91	1.1	1.9	2.0	2.0
10 / 2.5	2.5	4	410	440	490	1.0	1.2	1.3	3.0	3.1	3.4

§Signal at 90 cps with constant cell current.

‖Noise at 90 cps with a 7-cps bandwidth and with a constant current density.



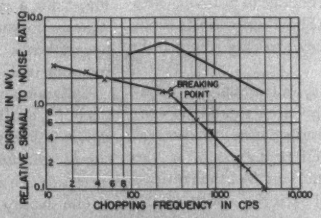


Fig. 7 (left). Incident angle versus signal. Fig. 8 (right). Signal and signal-to-noise ratio versus frequency. Here, an Eastman 2- by 2-mm cell at room temperature was used. The source was square-wave-modulated and the humidity was 40 per cent

Ektron PbS detector is shown in Fig. 8. The slow decrease of this curve at low frequencies is followed by a sharp drop after a certain critical frequency. The curve cannot be represented by a single time constant, and although the delay time of square wave pulses has been observed and time constants computed, the signal versus frequency curve is to be preferred, since it gives the more complete picture. Evaporated-type PbS cells usually do not show this low-frequency characteristic and therefore can be represented by a single time constant.

The temperature dependence of the signal is such that the signal increases when cooled. The only quantitative data available were those furnished for Ektron detectors, which show a signal increase of a factor of 9 when the cell is cooled from 20 C to −40 C.

PbS detectors are tested with the aid of a black-body source. The signal variation with source temperature for a black-body source is shown in Fig. 9. The spectral response, or wavelength dependence of the signal of a PbS cell, is the same as the wavelength dependence of the sensitivity shown in Fig. 10.

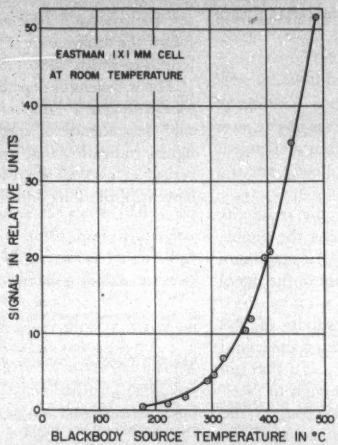


Fig. 9 (left). Signal versus source temperature.

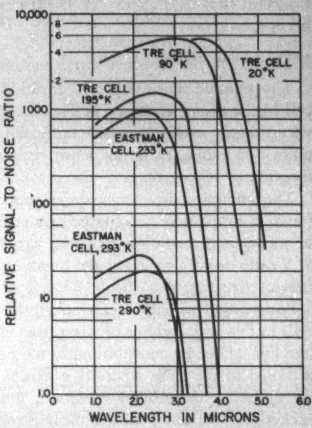


Fig. 10 (right). Wavelength versus signal-to-noise ratio

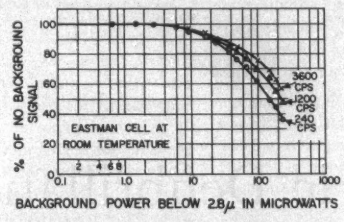


Fig. 11 (left). Signal versus background power. The data were taken under the following conditions: a black body temperature of 500 K; chopping frequency of 90 cps; bandwidth of 7 cps; and cells at room temperature

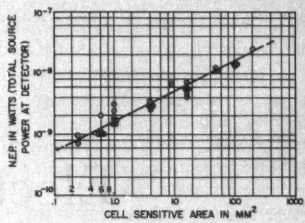


Fig. 12 (right). Sensitivity versus area.

Tests were made to determine the effect of a constant background radiation on the signal output of the PbS cell; the results are shown in Fig. 11. These curves were found to be independent of both the cell current (from .0 to 50 microamperes) and the signal-to-noise ratio (up to 10^4). It can be seen that the background effect is dependent upon the chopping frequency, which indicates that the optical response time or "time constant" is decreased as the background power is increased.

An attempt was made to determine experimentally the size and shape dependence of the signal. No definite conclusions about the area dependence of the signal could be drawn except that the trend seemed to indicate that the signal is independent of the area, under constant cell-current conditions. See Table I. The shape dependence of the signal could be proportional to the length-to-width ratio. But again, as with the resistance, deviation occurs at large length-to-width ratios.

The signal has been found to be proportional to the incident radiation power for small power. At higher intensities, the signal probably varies as the square root of the intensity.[7] Since the sensitive surfaces of PbS cells do not have a uniform signal sensitivity, when a very small source is used, these sensitivity contours can be mapped, each cell with its own distinct contour map. These non-uniformities restrict somewhat the optical design of systems using PbS cells, since any motion of the "circle of confusion" on the cell will cause spurious signals.

Sensitivity. The sensitivity of photoconductive detectors is usually expressed in terms of the noise equivalent power (nep) which is defined here as the total power from a black body of a given temperature (usually 500 K) required to give a signal equal to the noise of the cell. The nep is proportional to the noise-to-signal ratio and the smaller the nep, the more sensitive the detector. Of course, when given the nep of a cell and a source power, it is simple to compute the signal-to-noise ratio at the cell.

A typical nep value of 10^{-9} watt is obtained for a 0.5 by 0.5-mm Ektron PbS detector at room temperature, viewing a 500 K black-body source chopped at 90 cycles per second with a system bandwidth of 4 cycles. Using equations 1 and 2, the nep may be approximated by: nep =

Constant $G(f)/S(f)$ $(1/L^{1-k}W^k)$. If $k = 1/2$, this equation becomes:

$$\text{nep} = \text{Constant } G(f)/S(f)(1/(LW)^{1/2})\P \quad (3)$$

The relative sensitivity of a PbS cell, as a function of cell bias current, is shown in Fig. 5. The sensitivity rises very sharply at low currents until the current-dependent noise dominates, then the sensitivity is a slowly varying function of cell current.

The chopping frequency dependence of the sensitivity (or S/N ratio) may be obtained by combining the signal–frequency and the noise–frequency curves. The maximum S/N ratio usually occurs at the breaking point in the signal curve. See Fig. 8.

Background radiation can affect the sensitivity of PbS cells in two ways: either by saturation effects on the signal (see Fig. 11) or by contributing to the noise. If a PbS cell is cooled to the point where it is sensitive enough to "see" the ambient background radiation, the variations in the background will contribute to the noise output of the cell.[8]

The nep's of 50 Eastman cells of various sizes and shapes are plotted as a function of cell area. In general, they follow the square root of the area relation regardless of the length-to-width ratio. See equation 3.

The wavelength dependence of the sensitivity is shown for an Eastman cell** and a *TRE* cell[9] in Fig. 10. The temperature dependence of the sensitivity is also shown in that figure, indicating that upon cooling the cell exhibits an increase in over-all sensitivity and a shift to longer wavelengths of the long wavelength cutoff.

¶If the shape is other than rectangular, the current density must be considered and the sensitivity may be computed as a field problem using Poisson's equation with boundary conditions. It is also possible to approximate other shapes to the first order by a superposition of rectangular films.

**Data taken from graphs furnished by Eastman Kodak Company.

REFERENCES

1. Photoconductivity in the Elements (book), **T. S. Moss.** Academic Press, New York, N. Y., 1952.

2. New Photoconductive Cells, **R. J. Cashman.** *Journal*, Optical Society of America, New York, N. Y., vol. 36, 1946, p. 356.

3. Lead Telluride Cells for Infra-Red Spectroscopy, **O. Simpson, G. B. B. M. Sutherland, D. E. Blackwell.** *Nature*, London, England, vol. 161, 1948, p. 281.

4. Conductivity of Evaporated Films of Lead Selenide, **O. Simpson.** *Ibid.*, vol. 160, 1947, pp. 791–2.

5. The Theory of Metals (book), **A. H. Wilson.** Cambridge University Press, Cambridge, England and New York, N. Y., 1953, pp. 114–15.

6. Performance of Visible and Infra-Red Detectors, **R. C. Jones.** Advances in Electronics (book), vol. 5, Academic Press, 1953, pp. 1–96.

7. Electronic Processes in Ionic Crystals (book), **N. F. Mott, R. W. Gurey.** Oxford University Press, Oxford, England, and New York, N. Y., 1950, pp. 191–2.

8. **R. C. Jones.** *op. cit.*, p. 8.

9. Spectral Sensitivity of Lead Sulfide Layers, **T. S. Moss.** *Nature*, vol. 159, 1947, pp. 476–7.

Electric Defibrillation

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A series of animal experiments are reported that indicate the superiority of a-c defibrillation over the use of capacitor discharge or serial defibrillation in stopping fibrillation. However, the rapidity with which the procedure is instituted is crucial.

THE passage of an electric current through the heart may destroy its rhythm and throw the organ into a twitching state known as ventricular fibrillation. In this state the circulation ceases and, unless normal heart action is promptly restored, death ensues. Ventricular fibrillation is characterized by the absence of any pulse or heart sounds and can only be detected by an electrocardiograph. It occurs not only in electric shock accidents but also during surgery in hospitals. The only known method of arresting fibrillation is to send sufficient electric current through the heart to stop the twitching of the muscles. Then, when the circuit is broken, the heart usually resumes normal beating, provided the period of fibrillation was sufficiently brief.

Ventricular fibrillation may be arrested by sending either a capacitor discharge or a 60-cycle alternating current through the heart. It is the practice in hospitals to open the chest, and expose the heart, and place the electrodes directly on that organ. In hospitals, alternating current is used and currents of 1 to 2 amperes at 130 volts are sent through the heart either in a single continuous application about 0.5 second in length or in a series of six or more pulses each of about 0.1 second duration. The latter method is known as serial defibrillation. When a heart goes into ventricular fibrillation during an operation, the ventilation of the lungs is maintained by a breathing bag. With the chest open, it is possible to massage the heart and provide sufficient circulation of oxygenated blood to restore vigor

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to a heart that has become enfeebled by being in fibrillation for several minutes. Heart massage was not used in this electric defibrillation study, as it cannot be applied through the closed chest.

Ventricular fibrillation in electric shock accidents occurs most commonly when contact is made with low- and medium-voltage circuits or where a high circuit resistance limits the current that flows through the body. In electric shock accidents in the field, the defibrillating current must be sent through the heart by means of electrodes placed on the surface (skin) of the body, as it is not feasible to open the chest. In addition, the field method must be one that may be safely applied to a normal beating heart, because cardiographs are not available in the field.

THE RESEARCH

Because of the importance of this problem in the electrical utility field, the Edison Electric Institute provided funds for a study of the possibility of developing a method of recovering the fibrillating human heart. A method was sought which would make it unnecessary to open the chest and at the same time would not impair a normal heart.

EXPERIMENTAL PROCEDURE

Dogs weighing from 8 to 20 kg were used as the experimental animals. All of the animals were anesthetized and a tube was inserted in the trachea for positive pressure artificial respiration using a mixture of ether and air. During the periods that the heart was in fibrillation the ether was cut off and artificial respiration maintained with air only. After the hair had been clipped from the chest, an electrocardiogram of the normal heart action was taken. Then the heart was thrown into ventricular fibrillation by a 120-volt a-c shock. The presence of fibrillation was checked with the cardiograph. After the heart had been in fibrillation for the desired length of time, the defibrillating current was sent through the animal by means of electrodes applied to the skin of the chest. An electrocardiogram was then taken to determine the effect of the defibrillating current.

DEFIBRILLATING ELECTRODES

The efficacy of the resuscitating current in bringing the twitching ventricles to rest was studied for two directions of current flow. The current was sent through the chest in either the transverse (across the chest) direction or in the longitudinal or lengthwise direction. The electrodes used for the transverse path were of soft sheet copper each 4 by 6 inches in size. They were held in place on opposite sides of the chest by rubber bands. The electrodes, for the longitudinal path, were also of sheet copper each 5 by 5 inches in size. They were mounted on handles, and were pressed on the body in the desired position. One electrode was pressed against the upper end of the breast bone at the neck, the other was pressed upward against the diaphragm. To insure good contact, the surfaces of the electrodes were smeared with cardiograph jelly.

CAPACITOR DISCHARGE

The possibility of using a capacitor discharge to defibrillate a heart is an intriguing one. Unfortunately, there is little information available on the effect of capacitor discharges on the heart. Therefore the first capacitor studies were conducted on the exposed hearts of animals. These were followed by a second series in which the chest was not opened.

Open Chest. There were 135 defibrillating experiments made on the exposed heart. Each time the heart was allowed to remain in fibrillation without massage for a period of about 30 seconds. It was found that fibrillation could be stopped by capacitors ranging in size from 7.5 to 45 microfarads (μf) provided they were charged to not less than 600 volts and provided that the energy in the discharge was 5 watt-seconds or more.

When the heart was left in fibrillation without massage for periods of from 1 to 3 minutes, the capacitor discharge was only effective in 32 out of 57 experiments.

Closed Chest. With the data obtained from the experiments on the exposed heart, experiments were carried out on dogs with closed chests in which the capacitor discharge was sent through the body by electrodes placed on the surface of the chest. Capacitors of 50, 75, 100, 175, 250, and 1,250 μf charged to voltages of 4,000 to 450 volts were discharged through the chests of 35 dogs, whose hearts had been in fibrillation for 20 to 60 seconds. There were 13 successful recoveries and 22 failures. It was found that if the heart had been left in fibrillation for more than 25 seconds the changes of a recovery were very slight.

Capacitor Failures. Whenever two successive capacitor discharges failed to arrest ventricular fibrillation, recourse was had to alternating current. It became evident that the 60-cycle current was a more effective method of arresting fibrillation than a capacitor discharge. Therefore, attention became focused on the use of alternating current for defibrillation. This does not mean that the possibility of finding an effective capacitor discharge method has been abandoned. There exists an infinite number of capacitor combinations and there may be some unique combination of capacitance and inductance that will prove satisfactory. Although many have been tried, to date none has been found.

DEFIBRILLATION WITH ALTERNATING CURRENT

The experiments in which alternating current was used as the resuscitating means were all carried out on animals with unopened chests. Two methods were investigated, namely serial and a-c defibrillation.

SERIAL DEFIBRILLATION

In the initial tests alternating currents of 8 to 10 amperes were sent through the chest, in a series of pulses, each approximately 0.1 second in duration. These were applied by hand, at the rate of 1 pulse per second. They were effective in arresting fibrillation and special equipment was constructed for accurately controlling the duration of each pulse and the number of pulses per minute.

Hazard. In order to determine the hazard that existed, if serial defibrillation should be applied to a normal beating heart, tests were made on eight animals. In six of these cases, the animals' hearts were thrown into ventricular

fibrillation by the method. Therefore, the use of serial defibrillation, as a field method, was abandoned.

A-C DEFIBRILLATION

In this method the current was sent through the chest in a single application lasting about a second. Tests were made with the current flowing transversely across the chest and also with the current flowing longitudinally in the head-to-foot direction.

Transverse Direction. The electrodes were strapped on the opposite sides of the chest and a 60-cycle current of 8 to 12 amperes at 480 volts was sent through the chest. This current application was found to be effective in stopping ventricular fibrillation. This current path was used in 107 experiments. The hearts of the dogs were allowed to remain in ventricular fibrillation for the desired period before applying the a-c defibrillating current. The fibrillation was stopped in 68 per cent of the experiments.

The results are given in Table I. It is evident from this table that if the a-c defibrillating current can be applied within 1 minute after the onset of fibrillation that there is a 50-per-cent chance of a successful recovery. As the duration of the fibrillation increases, the chances of success become less.

Table I. Resuscitating Alternating Current Transverse Direction: Chest Electrodes Each 4 by 6 Inches on Opposite Sides of the Chest

Duration of Fibrillation (Seconds)	Number of Dogs				Percentage	
	Total	Fibrillation Stopped	Heart Beat	Lived	Defibrillated	Lived
30	12	10	9	9	83	75
45	11	10	9	9	91	82
60	37	26	16	16	70	43
75	11	6	3	3	55	27
90	11	6	3	3	55	37
105	4	2	1	1	50	25
120	10	5	0	0	50	0
150	8	5	0	0	63	0
180	3	2	1	1	67	33

Longitudinal Direction. A total of 58 tests have been made in which the electrodes were held on the surface of the chest by the operator; the current being sent through the animal in a head-to-foot direction. In these experiments the a-c defibrillating current values ranged from 4 to 6.25 amperes at 450 volts. The duration of the application was from 0.5 to 1.5 seconds, and the heart was left in fibrillation for periods up to 3 minutes. The fibrillation was stopped in 93 per cent of the experiments.

The results with the hand electrodes are given in Table II. If the heart had been in fibrillation for not more than 1 minute the chances of a successful recovery were 9 out of 10 and at 1.5 minutes, one out of 4. The table lists eight dogs whose hearts beat for only a few minutes following the defibrillation, and then ceased to beat because they were too weak to re-establish the circulation. It is well known that small electric impulses may be applied to the body and that these will produce effective beats. Perhaps these animals could have been saved had the necessary equipment been available.

Table II. Resuscitating Alternating Current Longitudinal Direction: Hand Electrodes Each 5 by 5 Inches, One on the Breast Bone at the Neck and the Other on the Stomach Pressing Up Against the Diaphragm

Duration of Fibrillation (Seconds)	Number of Dogs				Percentage	
	Total	Fibrillation Stopped	Heart Beat	Lived	Defibrillated	Lived
30	5	5	5	5	100	100
60	14	14	14*	13	100	93
75	6	4	1	1	67	17
90	24	21	14†	7	87	29
101	1	1	1	1	100	100
120	7	7	2‡	1	100	14
180	1	1	0	0	100	0

* One animal's heart beat for about 5 minutes. Its heart, however, was too weak to re-establish and maintain the circulation of the blood.

† Seven animals lived for several minutes.

‡ One animal lived for about 5 minutes.

Hazard. The hazard involved in sending an a-c defibrillating current of either 8 to 12 amperes transversely through the chest or 4 to 6 amperes in the lengthwise direction has been studied by sending the current through more than 50 animals with normal beating hearts. In not a single instance was there any injury, and a number of animals were kept for from 1 week to 2 months before being used in subsequent experiments. Autopsies of these showed no gross evidence of any trauma.

PROMPTNESS

The longitudinal method of a-c defibrillation has been successful in stopping fibrillation in hearts which have been in that state for as long as 10 minutes. However, the hearts of these animals were much too enfeebled by lack of oxygen to re-establish the circulation.

If the human brain, which is a delicate mechanism, does not receive a supply of oxygenated blood for a period of 5 minutes, it may deteriorate to such an extent that, should the shock victim be successfully resuscitated, he may be mentally deficient. Therefore, promptness in applying a-c defibrillation is just as important as in the starting of artificial respiration.

CONCLUSIONS

1. The capacitor discharge was found to be ineffective if the heart had been in fibrillation for more than 30 seconds.
2. Serial defibrillation was found to be dangerous to normal hearts.
3. A-c defibrillation using a single application of 60 cycles proved to be the best means of stopping fibrillation.
4. The longitudinal direction of flow of alternating current through the chest was more effective than the transverse direction.
5. A-c defibrillation did not injure a normal heart.
6. The problem now becomes one of finding a simple electric method of driving a heart that is too weak to re-establish the circulation by itself.

Reactor Maintenance Problems

C. B. WAGNER

Because of the hazardous nature of nuclear reactors, much automatic and remotely controlled machinery is employed. As the machinery and the reactor itself must be adequately serviced, it is this maintenance which presents personnel health problems.

DEVELOPMENT of the large production-type reactors, such as those in use at Hanford, Wash., has been greatly influenced by factors which have favored, and in many cases required, the widespread application of remotely controlled or automatically operated machinery. Thus, this new industry is furthering the growing trend towards so called automatic factories, wherein many operating functions are performed by machines either automatically controlled by suitable instruments, or operated remotely by a minimum of operating personnel. As a consequence of this development, a significant portion of the over all manufacturing responsibility is necessarily transferred from operating to maintenance personnel, and the role of the maintenance organization is becoming more vital.

The experience gained in reactor maintenance problems, based on several years' operation of the Hanford installations, emphasizes the importance of the many new considerations that are peculiar to this industry, and may provide background information to support evaluation of the magnitude of the maintenance function for future proposed reactors. In part, the maintenance problems of a reactor, its auxiliaries and instruments, are comparable to those of other modern industry, particularly of petroleum refineries or chemical processing plants, but with costly time-consuming complications that overshadow all normal considerations.

RADIATION AND CONTAMINATION

BASICALLY, the unusual nature of maintenance work on reactors and their auxiliaries stems from the fact that the various radiations generated in the inferno of a reactor —the alpha particles, beta and gamma rays, X-rays, and neutron particles—are injurious to human tissues, and the efforts at shielding a reactor, regardless of how extensive they may be, are necessarily not wholly effective. The intense radiations partially penetrate the shielding, particularly through any apertures, and furthermore, the many materials that are necessarily introduced into, or removed from, the reactor and exposed to radiation—the coolant, the fuel elements, the control mechanisms, the structural members, and the atmosphere within a reactor—may acquire an induced radioactivity or contamination that will spread this hazard. Consequently, measures to protect and control workers in locations in proximity to a reactor become vitally important.

This hazard is commonly considered in two rather broad and overlapping categories: radiation, which is an emitted ray or beam from radioactive materials; and contamination, which is radioactive material that has been reduced to minute particles, dust or gas, so it spreads easily from surface to surface and may be taken into the body readily.

Protection against radiation and contamination takes many forms, but, unfortunately, none of these particularly facilitates maintenance work!

To provide the necessary control on the movements of personnel in areas of potential hazard, radiation zones are established with specific safeguards stipulated for any work within the zone. These safeguards consist of time limits based on survey readings of the radiation level, protective clothing and equipment, special radiation monitoring devices, warning signs and barricades, and shielding.

TIME LIMITS

SINCE the deleterious effects of radiation are largely cumulative, a weekly permissible limit of radiation exposure has been established, and daily time limits are set for each radiation zone to ensure that a workman does not receive an exposure in excess of the limit. In the extreme case, maximum permissible exposures may occur within only a few minutes, so that even very simple maintenance work becomes complicated, consuming of manpower, and a problem requiring close scheduling Thus, on occasion a rather simple job, such as replacing a small electric motor, for example, may require a steady rotation of craftsmen so that the first workman may disconnect only a single lead, the second another, and so on until an entire crew may have recieved their permissible dose, and become no longer available for other radiation zone work during that day. Fortunately, jobs with these limits are the exception rather than the rule, and daily time limits generally range through more reasonable periods up to a maximum of the full eight-hour shift.

To measure the cumulative radiation exposure, accurate timekeeping must be provided in conjunction with a radiation survey prior to start of work and, if conditions are changing, with continuous radiation monitoring during the progress of the job. See Figs. 1 and 2. Also, the workers are required to wear suitable photographic film badges, pocket dosimeters, and occasionally finger ring or other film packs to measure the radiation to which they have been exposed.

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PROTECTIVE CLOTHING

MAINTENANCE WORK is further complicated by the protective clothing that is generally required in the radiation zones. Such protection is primarily directed against contamination: to prevent its spread or its introduction into the body. Protective clothing includes such items as coveralls (one or more pairs), foot protection (canvas shoe covers, British leggings, rubbers, or rubber boots), gloves (canvas gloves, rubberized or plasticized canvas gloves, surgeon's gloves and/or gauntlet rubber gloves), head protection (canvas caps or hoods), and masks (half-mask, assault mask, or respirator). See Fig. 3.

The experienced maintenance engineer may easily visualize the complications introduced in servicing a delicate instrument or electrical control device while wearing clothing such as two pairs of coveralls, a hood, assault mask, rubber gloves and canvas gloves, and rubber boots!

From a cost standpoint the handling of protective clothing also contributes significantly to the maintenance problem. Not only must the clothing be procured and stocked in adequate quantities of the properly assorted sizes, but careful control must be exercised following the use of such clothing to prevent its becoming a vehicle for the spread of contamination. A special contaminated laundry should be established to isolate this clothing, and each item surveyed individually following laundering to ensure that contamination has been removed.

Fig. 1. Radiation monitor surveys condition as maintenance craftsman starts work

Fig. 2. As work progresses, a radiation monitor continuously checks the radiation level, a time-keeper with his stop watch records exposure time, and a standby maintenance man waits his turn

DISPOSAL REQUIREMENTS

MATERIAL removed from the reactor or from many of its auxiliary systems usually presents the maintenance crews with a handling problem. If the equipment has a possible future use and is not too highly contaminated, decontamination efforts may reduce the contamination to the degree where repair or reworking of the equipment in a "hot shop" under properly controlled conditions is feasible. But frequently, disposal of the item is the only possibility, undesirable and expensive though it may be. Rather obviously, disposal is not just a question of transporting the item to a convenient scrap yard for eventual sale as scrap material, since such action would spread contamination and subject the general public to radiation hazards. Instead, burial grounds are established in isolated sections of the plant where such material may be safely buried under several feet of earth so that the radiation is properly shielded, and the material is inaccessible to the ever-present "pack rat" who may want to supply his home workshop.

Experience has repeatedly demonstrated the value of carefully mapping the exact location of all equipment in such a burial ground, since future emergency conditions often necessitate reworking material that previously had not been considered practical to use, or the decay of radioactive contamination with a short half-life may allow its future use under more reasonable restrictions.

Decontamination work is of value in some cases, but is far from a cure-all, since the decontamination solution with suitable cleansing action is just not available to replace the intensive washing usually required. It should be noted that, to be effective, decontamination must remove either a contaminating film adhering to the material, or the outer radioactive layer or surface of the material. Decontamination of personnel is further complicated by the fact that, important as it is to reduce the radiation below certain permissible levels, it is even more important not to break the skin and thus possibly introduce radioactive particles into the body.

ACCESS DIFFICULTIES AND SHIELDING

THE INHERENT DESIGN of reactor shielding usually embodies a difficulty of access to reactor auxiliaries that further complicates maintenance work. To prevent exposure of personnel to direct radiation beams under any conditions, piping and conduit runs, passageways, and duct work through the thick shielding walls are laid out in

labyrinth form. Therefore, not only are these systems awkward to reach, but repairs or replacement become major jobs.

Shielding does have its beneficial aspects, and supplementary shielding is widely used to cut down radiation exposures, and, thereby, to extend time limits or to reduce the protective clothing encumberances. Generally, such shielding involves erection of a lead brick wall, or "cave," around the source of the radiation, although other materials are sometimes utilized that may be more effective for the particular radiation encountered. Widespread use is made of a technique to dispose of extremely radioactive materials by manipulating them from a remote location into piping, or other suitable container, or "cask", and then burying the entire assembly. To accomplish critical jobs of this nature, the construction of mock-ups and training of personnel in repeated "dry runs" is frequently advisable, so that a single job may entail much of the elaborate preparation commonly associated with a movie production.

MATERIALS

In recent months considerable publicity has been given to the proposed use of many new and unusual materials, such as zirconium as a structural material, liquid metal coolants, and heavy-water moderators, which in the past have been encountered primarily in research laboratories. While most of these materials have not yet been utilized to such an extent as to create a maintenance problem, other little-known materials used in the construction of existing reactors necessitate new skills and techniques. Likewise, any work in conjunction with nuclear reactors that necessitates the introduction of materials into the reactor must involve careful re-examination of the proposed materials in terms of their nuclear properties.

Why must such unusual emphasis be placed upon reactor construction materials? Not only must the materials withstand high temperatures and extremely corrosive conditions, but also the effects of neutron bombardment and intense radiation on the material must be considered in the following respects:

1. Low neutron absorption rate, or low cross section, is of vital importance, except for those controls designed specifically for high absorption rate so as to control the reactor power levels readily.
2. Changes in physical properties of the materials, such as dimensional changes, brittleness, disintegration or decomposition of compounds must be considered.
3. Formation of highly radioactive contamination should be avoided insofar as is practical.

While these factors are first introduced in the design and construction phase of a reactor where their primary importance is recognized, the effect on maintenance work should not be overlooked. Several incidents that have been experienced in the field illustrate the unpredictable manner in which these problems may be evidenced.

A commonly used sealing compound was applied to a joint in the housing of a control mechanism where the compound was exposed to radiation under normal operating

Fig. 3. Maintenance mechanics don protective clothing prior to entering radiation zone

conditions. However, a short trial run indicated that not only did this material become highly radioactive, but also it was easily dispersed and soon became a prime source of contamination. So, its use was necessarily discontinued immediately and investigation of possible substitutes instituted.

In another case a minor explosion occurred within an expansion tank while maintenance craftsmen were drilling the casing. This particular tank was connected to a closed system which had been thoroughly flushed out a week previous, and had only contained pure water, so why the explosion? An investigation disclosed that the water apparently had decomposed into hydrogen and oxygen in minute quantities under the intense radiation within the reactor; the gases had accumulated as the result of a defective vent, and then had recombined explosively. Maintenance forces here had been fortunate in furthering their education regarding the wiles of a reactor with such a dramatic, yet fortunately, harmless demonstration.

Again, the insulation of thermocouple wiring in a critical application deteriorated so rapidly under exposure to high level radiation that it crumbled upon contact after several month's exposure. Likewise, the plastic tubing used to protect such wiring crystallized and became so brittle as to be of little value. Complete replacement of an elaborate wiring system was necessary in this case.

Commonly used forms of glass discolor badly when exposed to radiation and must be replaced frequently, or special types of glass, which have been developed to remain clear under these conditions, must be utilized. For ex-

ample, the lens of certain underwater lamps exposed to radiation soon became unusable, and electrical forces eventually designed a fixture in which a reflector flood-type lamp in a waterproof socket was immersed directly in the water and the lens dispensed with entirely.

Yet another complication in materials results from the corrosive nature of certain phases of the process. Stainless steel of various types is utilized to advantage except within the reactor where its intermediate absorption cross-section considerably limits its application. But the complications imposed in handling vast quantities of water exposed to elevated temperatures, and for which the optimum water treatment may not be usable because of radiation consideration, present another problem, although in this instance, one not uncommon in many industries.

SPECIAL TOOLS

In the original design of the Hanford reactors, pressure of more immediate problems prevented extensive provision of special tools and equipment for maintenance work on the reactors. However, since the reactor components were almost entirely unique in design and not generally available, as the need arose special tools were developed to handle many maintenance jobs—particularly where operating experience indicated repeated demands. While many of these tools were essentially local adaptations of commonly used equipment, in almost every case this application required consideration of use under unfavorable radiation conditions. As a result, a significant number of special tools have become a very handy adjunct to the usual facilities for maintenance work.

Widespread publicity has attended the application of various types of manipulators, or remote handling appliances, in the atomic energy industry, but this phenomenon has appeared primarily for laboratory or operating functions. However, a few vital maintenance manipulations may be performed, if required under emergency conditions, by remote operation of electrical, mechanical, pneumatic, or hydraulic tools from behind adequate shielding. It appears obvious that widespread use will be made in the future of closed-circuit television to view and guide such manipulations.

It is pertinent to note, also, that maintaining these remote tools presents quite a maintenance problem in itself. Here the mechanic deals with complex intricate machinery, usually constructed very compactly with miniature components to reduce size and weight, so located as to be inaccessible much of the time, and invariably exposed to radiation and contamination.

INSTRUMENTATION

The instrumentation problem merits special attention because of its extraordinary importance in reactor operations. Here a new industry, which is necessarily acquiring some characteristics of an automatic factory, deals with factors which cannot be perceived directly by the human senses, yet are hazardous to humans. So the maintenance of many diverse forms of instrumentation, which measure radiation as well as such quantities as pressure, temperature, flow, and motion with electronic, pneumatic, hydraulic or other types of sensing elements, is imposed on the servicing personnel of a reactor plant. See Fig. 4. The magnitude of this assignment may be conveyed in part by the fact that the instrument maintenance crews are considerably larger than the electrical maintenance crews in a plant where installed motor capacity is measured in tens of thousands of horsepower.

Closely related to the instrumentation problem is that of the various control mechanisms. The multiplicity of control elements, each involving intricate electric or hydraulic systems for which split-second response times are necessitated to control power levels, involves special maintenance consideration both because of the special skills and techniques required, and because of the total volume of servicing.

MISCELLANEOUS FACTORS

Several additional complications in reactor maintenance should be noted briefly in passing. First, the physical isolation, thus far dictated by safety and security considerations for production-type reactors, has greatly increased the time consumed by maintenance forces in travel to job sites and in transportation of equipment and materials; has required the development of unusual self-reliance of the maintenance department, since supplementary shops, supplies, and facilities usually conveniently located near other major industries just are not available; and has emphasized the importance and value of an adequate, well-planned stores and spare-parts stock. This factor is of particular import at the Hanford Works, since the several operating areas are isolated in a desert reservation approximately two-thirds the area of Rhode Island.

Second, while this industry can not be described accurately as highly competitive, still the demand for the product is so well sustained that production requirements are paramount and maintenance programs must be properly planned, closely scheduled, and well-justified to merit consideration.

Fig. 4. Maintenance of many diverse forms of instrumentation is imposed on the servicing personnel of a reactor plant

Third, the security implications are ever-present in the maintenance picture, and are primarily of importance insofar as security measures introduce another time factor in maintenance scheduling: delays in recruiting needed personnel because of clearance requirements, delays in transporting men and materials to job sites, and delays in transmitting, or obtaining, needed information.

CONCLUSIONS

What is the net effect of these complications on the overall maintenance costs for a reactor plant? Quantitative figures are partially obscured by security implications, and in many cases would be misleading since a generalization may not be applicable to the specific case. However, the empirical curve shown in Fig. 5 illustrates rather simply the increased labor time predicted on the average for radiation zone work compared to similar work under normal conditions without radiation zone restrictions. Actually, field experience shows that an individual survey of each job is usually advisable, since the cumulative effects of the many diverse factors involved in a specific case may greatly distort this relationship.

As an indication of the magnitude of the reactor maintenance problem, experience at the Hanford plant demonstrates that the maintenance organization contains approximately 35 per cent of the operating personnel in the field and is responsible for the expenditure of approximately 20 per cent of the total operating budget of the reactor field organization. On the average, for each dollar of direct labor charges approximately 25 cents is expended for materials.

Lest the foregoing resume of maintenance problems with production-type reactors appears too formidable or insurmountable, it should be noted that the Hanford reactors are being maintained—even being improved—so that total production is increasing regularly despite these complications. And the precautions observed in safeguarding this maintenance work have been so effective that no known cases of injury resulting from overexposure to radiation have occurred.

At the same time, this maintenance work is expensive, time-consuming, and demanding of the utmost skill, ingenuity, and patience on the part of maintenance craftsmen and their supervisors.

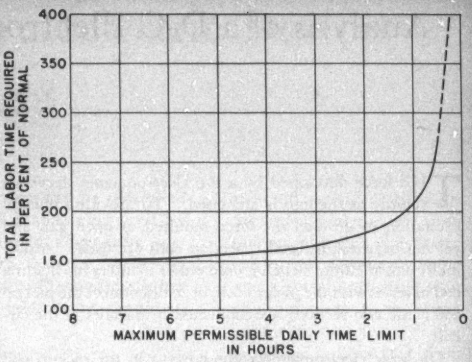


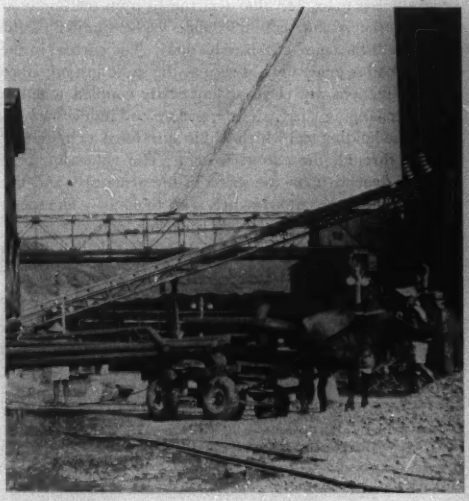
Fig. 5. Average effect of time limits on labor costs for radiation zone work

Power Plants Are Being Constructed in Far East

Formosa will soon have two of the most modern steam-electric power plants. They are being constructed at Peipu in the northern part of the island and at Nanpu in the southern section. Gibbs and Hill of New York, N. Y., is serving the Taiwan Power Company as their engineers in connection with design, procurement, and supervision of construction for the Nanpu station, while Westinghouse Electric International Company, New York, N. Y., supplies equipment and services for the Peipu station. The Power Piping and Sprinkler Division of the Blaw-Knox Company, Pittsburgh, Pa., are fabricators and erection supervisors of power piping for both plants.

While the plants will be built according to the latest specifications, the means and methods sometimes employed in working under Formosan conditions with native labor, have presented problems in construction. Oxen, as shown, are used to transport pipe from docks to the plant site.

The Peipu plant will produce 40,000 kw of electricity from two units, operating at 920 psi at a temperature of 925 F. The Nanpu plant will eventually have an output of 200,000 kw. The first of two 40,000-kw turbogenerators, operating at 950 psi and 900 F will be constructed now.



Analysis of a D-C Electromagnet with Cutout Switch

T. H. LEE
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THE force developed by a d-c electromagnet decreases rapidly as the gap is increased. To provide sufficient excitation to develop the force required at open gap and yet not overheat the coil, 2-section coils are used. A normally closed cutout switch is used either to insert the holding coil in series with the pickup coil, or to disconnect the pickup coil if the two sections are connected in parallel in the circuit.

On large electromagnets, the current in the pickup coil may be so high that the switch is unable to extinguish the arc. A capacitor can be used to improve the interrupting ability of the switch. For this discussion, the cutout switch is connected across the holding coil, and the capacitor is connected in parallel with the switch. The two sections of the coil are connected in series.

Without a capacitor, the switch must force the arc to become unstable for interruption. With the capacitor, the voltage across the switch at the instant of opening is zero. A considerable recovery strength is developed almost immediately.

Unless the voltage across the cutout switch becomes higher, at a later instant, than the recovery strength, there will be no arc at the cutout switch. The capacitor across the switch therefore changes the principle of interruption from forcing the arc to become unstable to preventing restriking across the contacts.

The voltage across the cutout switch after it is opened depends upon the currents in the pickup and the holding sections of the coil at the instant of opening. The current in the pickup coil at the instant of opening of the switch is generally less than the value determined from the line voltage and the pickup coil resistance. The motion of the armature is the cause of this reduction. The current in the holding coil is generally not zero at the same instant, since the two sections are electromagnetically coupled together and the changing current in the pickup coil induces a voltage in the holding coil which will in turn force a circulating current through the cutout switch. The values of these currents depend upon the speed of the armature, and the position where the cutout switch is set to open. The speed of the armature depends largely upon the load.

The voltage across the cutout switch is calculated with the following approximations:

1. The pickup coil resistance is much smaller than the holding coil resistance.
2. The sum of the pickup coil inductance, the holding coil inductance, and twice the mutual inductance is much greater than the product of the pickup coil resistance, the holding coil resistance, and the capacitance.
3. The coupling between the pickup coil and the holding coil is perfect.
4. The pickup coil current prior to the opening of the cutout switch has a negative slope. This descending portion can be approximated by a parabola.

By using the appropriate value for all the inductances, the current in the holding coil at the instant of opening of the cutout switch can be calculated. The voltage across the cutout switch can then be solved by operational mathematics.

The results indicate that:

1. For the same current in the pickup coil at the instant of opening of the cutout switch, the faster the armature speed, and the higher the voltage will be across the cutout switch.
2. For the same armature speed, the higher the pickup coil current at the instant of opening of the cutout switch, the higher the voltage across the cutout switch.
3. The highest voltage across the cutout switch generally occurs if the current in the pickup coil, at the instant of opening of the switch, is equal to the line voltage divided by the pickup coil resistance, and the current in the holding coil at the same instant is zero. This situation is never encountered in actual operation. The voltage for this case may be more than twice as much as the voltage in actual operation.

The use of constant inductance gives a value of voltage across the cutout switch higher than the actual value. The inductances increase as the armature travels toward its sealed-in position. The energy stored in the pickup coil at the instant of the opening of the cutout switch is then

$$1/2\ LI^2$$

This stored energy cannot increase after the cutout switch is opened. As L is increased, the magnetic field tends to maintain a smaller current. This decrease in current is directly responsible for the lower voltage across the cutout switch.

There are instances where the speed or the position of the armature as a function of time is required. This can be calculated by the step-by-step method illustrated by Roters[1] or by the numerical method illustrated in the paper with the aid of a pull curve and a magnetic oscillogram of current.

Digest of paper 55-85, "Transient Analysis of a D-C Electromagnet with Cutout Switch," recommended by the AIEE Committee on Industrial Control and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Applications and Industry*, 1955.

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REFERENCE

1. Electromagnetic Devices (book), H. T. Roters. John Wiley and Sons, New York, N. Y., 1941, pp. 373–91.

A-C Release of Thermoelectric Devices

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MEMBER AIEE

The operation of gas burners can be controlled by thermoelectric shutoff devices energized by a pilot flame. By superposing alternating current on the thermoelectric current, these devices can be made to operate in response to other situations in addition to pilot flame condition.

THE SIMPLEST system for automatically controlling the operation of a gaseous fuel burner makes use of a pilot burner, which is supplied with gas continuously, and a main burner which is supplied with gas intermittently in accordance with heating requirements. As long as the pilot flame functions, ignition will occur at the main burner whenever a thermostat or other control device calls for main-burner operation and supplies fuel to that burner. However, situations can develop in practice during operation of this simplified control system which will interfere with the flame at the pilot burner and may result in its extinction. Upon subsequent call for main burner operation, unignited fuel will then be admitted to the appliance. Thus, safety requirements dictate the use of a flame detector and control which, in the absence of a pilot flame, prevent the flow of fuel to the main burner upon demand for such fuel flow.

In 1950 an AIEE paper[1] described the various flame detectors for fuel-burner safety devices. Briefly, these respond to the temperature of combustion products, total radiation from the flame, luminous radiation from the flame, or electric conduction by the flame. It was indicated that approximately 70 per cent of the currently installed flame detectors for gas pilots are of the type employing a thermocouple heated by the pilot flame and supplying thermoelectric current to the winding of an electromagnetic safety device. This device is arranged so that as long as the thermoelectric current exceeds a predetermined value, gas may flow to the main burner; however, should the thermoelectric current fall below this value, as upon extinction of the pilot flame or reduction in its size due to a partial stoppage in the supply line, the safety device will operate and prevent the flow of gas to the main burner upon subsequent thermostat operation.

SAFETY SHUTOFF DEVICES

THE operating principle of thermoelectric safety shutoff devices is quite simple. Fig. 1*A* illustrates an arrangement in which a thermoelectrically energized valve controls a main burner and has a pilot burner that receives its fuel from a supply line connected ahead, i.e. to the inlet side, of the safety valve. A manually controlled valve is shown in this pilot line for controlling the supply of fuel to the pilot burner. In the thermoelectric main burner valve, a valve stem and disk are shown which are urged to the closed position by a spring, the outer end of the valve stem being attached to the armature of an electromagnet. In the closed position of the valve disk, the armature is separated from the pole faces of the electromagnet core, the latter being provided with a magnet winding directly connected to the thermocouple.

To put this system into operation, it is first necessary to open the valve in the pilot burner supply line and to ignite the fuel issuing therefrom manually. After the thermocouple has been heated sufficiently by the pilot flame, upward movement of the resetting push rod removes the valve disk from its seat and supplies gas to the main burner. It also moves the armature into contact with the pole faces of the electromagnet core, see Fig. 1*B*. If sufficient thermoelectric current flows through the electromagnet winding, release of the resetting means, as shown in Fig. 1*C*, results in the armature being held in the attracted position and the valve remaining in the open position, and operation of the main burner may go on continuously. If for any reason the pilot flame changes so as to reduce the flow of thermoelectric current below a predetermined value, the armature is released by the electromagnet under the action of the spring and the valve closes, thereby discontinuing the flow of gas to the main burner.

Thermoelectric devices are available commercially from a number of manufacturers in both valve and switch models.

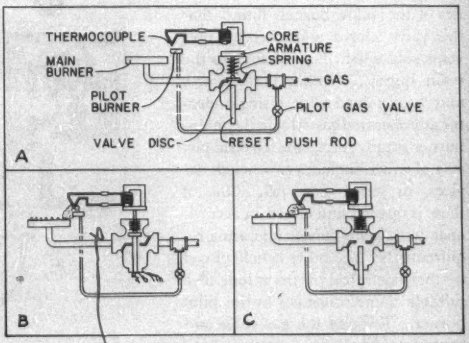

Fig. 1*A*. Simple control system showing the thermoelectric valve in the closed position. Fig. 1*B*. Thermoelectric valve in resetting position. Fig. 1*C*. Thermoelectric valve in open position

Full text of conference paper CP55-237 presented at the AIEE Winter General Meeting, New York, N.Y., January 31–February 4, 1955 and recommended for publication by the AIEE Committee on Domestic and Commercial Applications.

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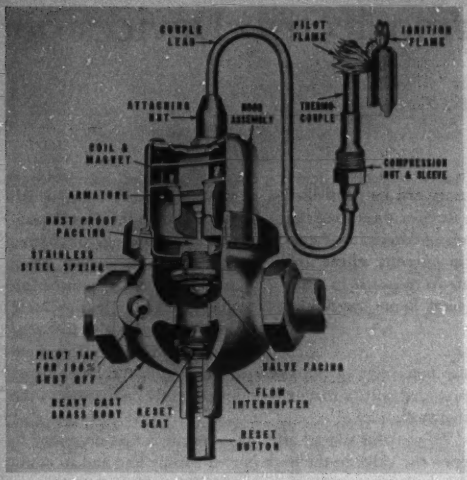


Fig. 2. A cutaway view of a thermoelectric valve

Fig. 2 illustrates a commercial valve model in which the flow of gas to the main and pilot burners is prevented when the valve is in the closed position and gas may flow to the pilot burner alone during the resetting operation. Fig. 3 illustrates a switch model in which the switch is normally closed when the armature is in the attracted position and is opened upon failure of the pilot flame. A concentric type of thermocouple is shown in Fig. 4.

A commercial form of the control system here considered employs two valves in the supply pipe to the main burner, Fig. 5*A*. One of these opens and closes in response to heating requirements and is under the control of a thermostat or other device, and the other valve is under the control of the thermoelectric current and remains open until abnormal conditions so influence the characteristics of the pilot burner flame that this valve closes and thereby prevents subsequent flow of fuel to the main burner. Similar performance may be obtained with a single electrically operated gas valve in the main-burner supply pipe, the electric circuit of which includes two switch devices in series, Fig. 5*B*. One of these is opened and closed in accordance with main burner operating requirements; the other is held closed by thermoelectric means as long as a suitable flame continues at the pilot burner. To open the gas valve and cause main-burner operation both switches must be closed. The valve will close and discontinue burner operation when either switch is opened.

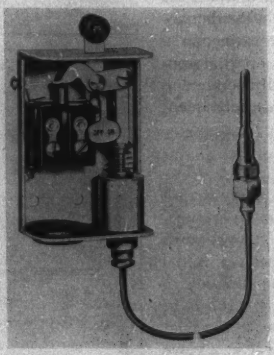


Fig. 3 (above). A thermoelectric switch here shown with the cover removed

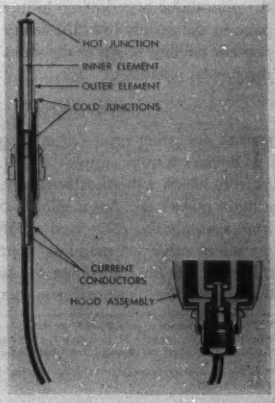
A-C RELEASE

THE only function of the thermoelectric device which has thus far been discussed is to prevent unignited gas from issuing from the main and pilot burners should the pilot flame be extinguished or reduced to unsafe proportions. It is the purpose now to describe means by which the thermoelectric device may be made to operate for reasons other than pilot flame failure.

Situations may develop during operation of an automatic control system in which pilot operation is normal, yet because of malfunctioning of another element as, for example, the main thermostatic control device, the main burner might be kept in operation past the point at which it should normally be shut off. This would result in overheating and perhaps the development of a dangerous situation, under extreme conditions. The added function in this case is one of limit control operation, in which, should excessive temperature or pressure be developed in the medium being heated, the shutoff valve will close even though a normal pilot flame exists at the thermocouple.

There may also be situations in which the thermoelectric device is to be operated to discontinue gas supply as a regular operating procedure. These objectives may be accomplished by superimposing alternating current on the thermoelectric current[2] when a limit control or routine action is required. This can best be understood by reference to Fig. 6*A*, which shows the decay of the thermoelectric current through the electromagnet winding when the pilot flame is extinguished. It will be noted that prior to extinction of the pilot flame at time T_0, the thermoelectric current through the electromagnet winding I_W has a value I_H. A current value I_0 is indicated, which is the predetermined or drop-out value of the thermoelectric current at which the spring of the safety device removes the armature from the electromagnetic core and closes the valve. As long as the current I_W in the electromagnet winding exceeds the value I_0, the safety valve will remain open. Fig. 6*A* shows the thermoelectric current values following pilot flame extinction at

Fig. 4 (below). A cutaway view of a thermocouple and electromagnet



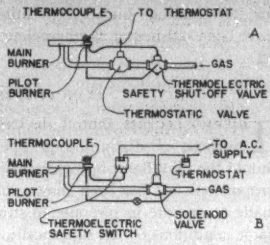


Fig. 5. An automatic control system using: (*A*) a thermoelectric valve; (*B*) a thermoelectric switch

time T_0 and indicates that at time T_1 the current has reached the operating value I_0, whereupon the valve closes. Assuming that the thermoelectric current remains at its normal value I_H, should limit control or routine action by a-c release be desired, the superposition of alternating current of maximum value I_{AC} on the thermoelectric current results in a net current I_W through the electromagnet winding as shown by the solid line in Fig. 6*B*. It will be noted that when $I_{AC} > I_H - I_0$, the net current reaches a value I_{min} which is less than the drop-out current I_0. During the time I_W is less than I_0 the armature may move away from the pole faces. With a suitable value of I_{AC} this movement is such that the armature cannot be recaptured even with a severalfold increase in ampere-turns. Hence, when the armature moves away from the pole faces, the succeeding maximum value of the net current I_W is unable to pull the armature back and the device moves to its shutoff position.

The source of alternating current may be connected in series or in parallel with the thermocouple. These arrangements are indicated diagrammatically in Figs. 7*A* and 7*B* where terminals *1* and *2* are the terminals to which the a-c supply is connected. In the case of the series arrangement of Fig. 7*A*, the electrical resistance introduced between terminals *1* and *2* is limited to relatively small values since the total resistance of the thermocouple, leads, and magnet winding is only a few hundredths of an ohm (in a typical case the output voltage of the thermocouple is on the order of 0.017 volt and the current flow is about 0.4 ampere). Excessive resistance inserted between these terminals will reduce the holding force of the shutoff device and must be avoided. In the parallel arrangement of Fig. 7*B* high resistance in the connected circuit is desirable. This prevents excessive thermoelectric current from being diverted from the electromagnet winding during normal operation. Only that portion of the alternating current that flows through the electromagnet winding is effective in causing operation of the shutoff device.

A simple arrangement for supplying alternating current to the thermoelectric circuits shown in Figs. 7*A* and 7*B* is indicated in Fig. 7*C*. Here a transformer *T* has its low-voltage winding *L* connected to terminals *1* and *2* which may be connected to terminals *1* and *2* in Figs. 7*A* or 7*B*, the resistance of winding *L* being determined in accordance with the considerations stated above. The high-voltage winding *H* is connected to the a-c supply through a normally open switch *SW*. The limit control or other device closes this switch to energize the transformer when predetermined temperature or pressure conditions arise in the medium heated by the gas burner or when routine operation requires discontinuance of burner operation.

It will be noted that in Fig. 7*C* the limit control or other device *closes* the circuit at switch *SW* to obtain a-c release of the thermoelectric device. Should a wire be broken in the high-voltage circuit or the contacts of switch *SW* fail to close, a-c release would not be obtained even though the limit control or other device may try to shut down the burner. An alternate arrangement is indicated schematically in Fig. 7*D*.[3] Here two similar transformers T_1 and T_2 are employed, having high-voltage windings H_1 and H_2 and low-voltage windings L_1 and L_2, respectively. The low-voltage windings are connected in series and to the output terminals *1* and *2* and to terminals *1* and *2*, of either Fig. 7*A* or 7*B*. The high-voltage windings are connected in parallel with the a-c source, the transformers being so connected that when both high-voltage windings are energized, the voltages at low-voltage windings L_1 and L_2 oppose each other, hence there is no a-c output to the terminals *1* and *2*. A switch *SW* is provided which controls the energization of

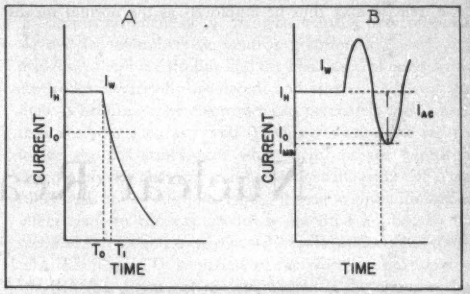


Fig. 6*A*. Graph showing the current to the electromagnet winding upon pilot flame extinction. Fig. 6*B*. The current to electromagnet winding with superposed alternating current

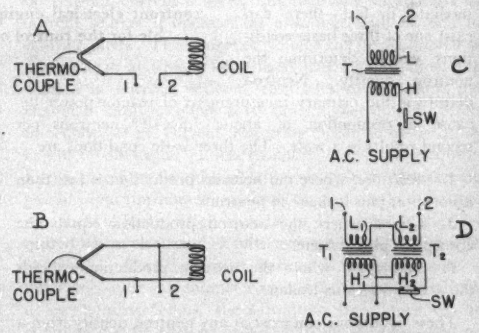


Fig. 7*A*. A thermoelectric circuit with series insertion of alternating current. Fig. 7*B*. A thermoelectric circuit with parallel insertion of alternating current. Fig. 7*C*. Single transformer energization. Fig. 7*D*. Twin-transformer energization

one of the high-voltage windings as H_2 and this switch is actuated by the limit control or other device intended to terminate operation of the main burner. Thus, when switch *SW* is closed and the output terminals *1* and *2* are connected either in series or parallel with the electromagnet winding, as in Figs. 7*A* and 7*B* respectively, no alternating current is superimposed on the thermoelectric current. However, when operation of the thermoelectric device is required, opening of switch *SW* de-energizes high-voltage winding H_2 and removes the voltage at L_2 in the low-voltage circuit which opposes the voltage of low-voltage winding L_1, thereby introducing alternating current into the output terminals *1* and *2* of the arrangement. If this arrangement is employed with the low-voltage windings in series with the thermoelectric circuit, as in Fig. 7*A*, it is fail-safe to the extent that a break in the high- or low-voltage circuits or contact failure in switch *SW* will cause the thermoelectric device to discontinue burner operation.

The a-c release method here described has the advantage that it may be applied to any standard thermoelectric shutoff device by the use of an external connector which introduces alternating current into the thermoelectric circuit. Connectors for this purpose are available commercially. A-c release may thus be employed as the normal means for terminating burner operation when requirements have been satisfied or as emergency means for burner shutoff.

CONCLUSION

THERMOELECTRIC shutoff devices are available for the purpose of discontinuing operation of gas burners should the pilot flame be extinguished or decreased to unsafe proportions. It has been shown that these devices can be made to operate in response to situations other than pilot flame conditions by the superposition of alternating current on the thermoelectric current flowing through the electromagnet winding. A-c release may be employed for limit control operations or as the usual means to terminate burner operation.

Simple connectors are available for use with commercial thermoelectric devices by which alternating current may be introduced into the thermoelectric circuit.

REFERENCES

1. Flame Detectors for Domestic Fuel Burner Safety Devices, **J. A. Deubel.** AIEE *Transactions*, vol. 69, 1950, pp. 220–25.
2. Thermoelectric Device, **P. L. Betz,** *U. S. Patent 2,505,730,* April 25, 1950.
3. Electrical Energizing Means for Limit Control Devices and the Like, **P. L. Betz,** *U. S. Patent 2,569,397,* September 25, 1951.

Nuclear Reactor Control

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Attention is called to the fundamentals of the nuclear reactor art as it is practiced. Special attention is given to certain problems which confront electrical engineers who are responsible for the control of nuclear reactors.

NO MATTER what type of reactor is to be controlled—thermal, intermediate, or fast—there can exist one of three basic conditions which determine the neutron density. Neutron density is the primary measurement of reactor power because a production of about 7.5×10^{10} neutrons per second results in a watt. The three basic conditions are

1. *Subcritical* where the neutron production is less than absorption plus leakage of neutrons.
2. *Critical* where the neutron production equals the absorption plus leakage.
3. *Supercritical* where the neutron production exceeds the absorption plus leakage.

These conditions can exist at any neutron density from a microwatt up to a design power maximum in megawatts. To give continuous instrumentation a suitable neutron-producing source such as a few grams of radium in close proximity to beryllium has been designed into the reactor. This provides the instruments with a reasonable neutron density to read under all power conditions. This source must be so located that, to reach the instruments, the neutrons pass through the reactor core which contains the fissionable material. If the source were placed too close to the instruments, it would blind them to neutron production which was going on in the reactor core.

For any of the three conditions the basic method of control is the same. For example, consider the case where production is less than absorption plus leakage. With a built-in source of neutrons, a constant neutron density in the reactor will be reached, which will increase only if (1) fissionable material is added (increase neutron production); (2) reflecting material (to reduce neutron leakage) or alternately moderator material which is added, reduces the neutron

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energy (and subsequently the leakage); (3)built-in absorber material is removed, such as cadmium or boron, which does not produce neutrons. It should be remembered, however, that as long as this condition called subcritical prevails the neutron density will always reach some constant value.

Here then are all the fundamentals of control. To change neutron density all that needs to be done is to change one of the three: production, absorption, or leakage.

Next, examine the critical condition where an equality exists between production and absorption and leakage. The neutron density will rise at a constant rate depending upon the number of neutrons injected per unit time by the source. If the source is removed, the neutron density will remain constant. In some experiments run specifically for determining critical reactor loadings, the source is removed when a critical loading is reached to be sure no error is introduced by the source.

It is readily apparent that at very high neutron densities the effect of any practical source would be too small to affect criticality. If this were not so, reactors would not be needed to produce large quantities of neutrons; they could be obtained directly from the source.

The third condition in which production exceeds the absorption and leakage will be shown by an exponential rise in the neutron density. The period of the exponential rise is shorter as the production excess becomes larger.

These conditions in the reactor are designated by referring to the quantity k or, more exactly, k effective where k is the number of neutrons produced for each neutron absorbed in fission which returns to fission again. For example, with the first condition of a production deficiency, k is less than 1. Further, taking $(k-1)$ obtains the control parameter δk called reactivity with which the control engineer deals continuously. The units of this quantity being neutrons per neutron, it is dimensionless.

If a reactor period is to be related to reactivity, a time unit is needed. It is supplied by the average neutron lifetime in the reactor. This quantity usually designated ℓ can be as long as 1 millisecond in thermal energy nuclear reactors or very short, 10^{-6} second or less, in fast or high-energy reactors.

At this point, the effects discussed could be reduced to simple exact formulas if it were not for the delayed neutrons. The effect of delayed neutrons is to lengthen the reactor period. The percentage of neutrons delayed varies with reactor types, but is about 0.76 per cent of the total neutrons produced. Delayed neutrons have an effective period of about 10 seconds and are very useful control aids because they lengthen the reactor period and allow more time to regulate the neutron density changes by controlling reactivity.

NEUTRON DENSITY MEASUREMENT

So far, it has been pointed out that the control engineer's problem is to measure relative neutron density and density changes, thus determining the reactivity of the reactor. Consider now how this neutron density measurement is made.

It should be kept in mind that the important quantity to read is the reactor's average neutron density. In most power reactors the neutron density is far from uniform due to local absorption by built-in rods, placed there for the specific purpose of varying the neutron absorption to control the neutron density. Therefore, the instrument should be placed a few feet from the reactor core so that neutrons reaching it come from all parts of the core. A hole, tangential to the reactor core and located in the shield, is usually provided so that as the instrument is moved back along the hole more shield is introduced between the instrument and the reactor core. This provides a convenient way of keeping the neutron detector in a measurable neutron density as power or neutron density is increased.

If instead of absorbing rods in the reactor a reflector were being moved to control the neutron density, through neutron leakage changes, location of an instrument to measure average neutron density in the core could present a problem. The removal of reflector material might cause an increased neutron leakage directly toward the instrument. Here, then, is an important point upon which the control engineer concentrates so that his instrumentation will produce logical information about the average neutron density in the core.

NEUTRON DETECTORS

For measurement of the neutron density, neutron-sensitive ion chambers or neutron counters are used. In principle, these are similar and are composed of conducting electrodes electrically insulated, and surrounded by a gas such as helium. The electrodes can be coated with a neutron absorber such as boron which gives off alpha rays to ionize the gas atmosphere when neutrons are captured. Alternately the chamber can be boron trifluoride (BF_3) gas filled with uncoated plates giving the same alpha ionization effect right in the gas. With a potential applied to the electrodes, an electric current will result proportional to the gas ionization. This current is, therefore, proportional to the neutron density at the chamber. If the chamber has been placed strategically, the current is proportional to neutron density in the reactor.

The design of these chambers is of first importance to the control engineer. Properly designed, they are supposed to be constant-current sources, but they are only constant-current sources if operated at a voltage high enough to saturate them. The saturation voltage can be designated as that voltage at which, for a fixed ionizing radiation, the change in current between electrodes divided into the change in applied voltage is 10^3 times higher than the input impedance of the current-measuring circuit to be used. A complete discussion of ion chamber impedance requirements, therefore, would start with a discussion of measuring circuit input impedance requirements and would constitute an article in itself. High impedance, 10^{14} ohms, is often required where electronic circuits are used in connection with chambers. If the chamber current is measured with a laboratory-type galvanometer having an impedance of only a few hundred ohms, the saturation impedance of the chamber can be allowed to fall to 10^6 or 10^7 ohms and no too-significant measuring error would result.

For power reactors a detector may be required to cover a range of neutron density changes as high as 10^{12} to follow the neutron intensity from source level to full power.

Several chambers are usually provided, as well as separate types of sensing instruments for complete range coverage either because of minimum current-sensitivity limitations in the measuring circuit, or the maximum limit of current output allowable for the chamber.

For very low neutron densities, counting chambers are used where individual pulses resulting from infrequent neutron absorption are counted by means of electronic counting circuits.

Counters are always used for initial reactor start-up, although electronic circuits working on continuous-current ion chambers are satisfactory. It is quite comforting to use these two types together in this exploratory stage of operation so that one does not have all one's "eggs in one basket" from a measurement standpoint.

To exemplify this condition, suppose the ion chamber were connected backward. The electronic amplifiers have a fundamental noise component equal to or greater than the neutron signal at low densities. The display instrument, such as a commercial millivolt recorder, will follow the amplifier noise and give the impression that it is following the small initial neutron multiplication changes. The first indication that something is wrong would come when this instrument hugged the zero line very tightly because the increasing neutron-produced reverse signal finally overcame the amplifier noise. At this time, the reactor may be well on its way to high power on a very short and damaging period. Counters, on the other hand, if they are working at all, will give a positive indication.

When the reactor neutron density is raised to a level where useful power is produced, as in a nuclear power plant, detection of the neutron density is no problem. A well-designed ion chamber can be made about 1,000 times as sensitive to neutrons as it is to fission product gamma. This is accomplished by using a plate spacing such as 3/16 inch. At full power the ionization due to gamma rays from the reactor in this small chamber volume is actually considerably less than the high alpha ionization due to neutron capture.

In heavy-water reactors the fission product gamma, which decays very slowly, produces a large number of neutrons because of a gamma-neutron reaction which takes place in heavy water. Therefore, in that type of reactor a strong signal is always available.

Light-water (H_2O) moderated types introduce a complication because this gamma–neutron reaction is not present to any useful extent. The gamma will render the chamber blind to neutrons at low power and during reactor start-up after full-power operation.

To circumvent this problem gamma-compensated chambers are used in which one half the volume is made insensitive to neutrons and the other half is made sensitive to both gamma and neutrons. If the current from each half is electrically opposed, the net current will give a neutron measurement. Naturally one might expect that this compensation could only be made to some fixed degree of accuracy. In practice, this procedure is effective in extending the chamber range about 2 to 3 decades below that neutron density which it could cover if it were not compensated.

NEUTRON DENSITY CONTROL

To complete the control loop, there must be both the measurement of the process which goes on in the reactor and a control means with which the process can be regulated. This control can be effected, as previously pointed out, by changing either production or leakage or absorption of neutrons or, of course, by combinations of these effects.

In order to restrict this discussion to a finite length, this article deals only with the most common method of carrying out this control objective in proposed power reactors, namely, mechanical movement of rods carrying fuel, absorber, or reflector materials. Many ingenious ideas have been presented, very few of which have been tried, for the control of the nuclear process and this is certainly one field of endeavor in which engineers can contribute to practical reactor development. In the end, mechanical rod movement inside of the core usually is utilized.

The kinetics of the movement of rods to effect good reactor control is different for every reactor type. However, certain general specifications which must be met for all reactors using mechanical rods can easily be drawn up:

1. The rods must be able to increase or decrease reactivity at rates of about 10^{-5} δk per second. A typical mechanical control speed corresponding to this δk-per-second figure would be about 0.1 inch per second. Control of this movement should be from a remote point. Variable speeds to increase this rate five to ten times are convenient. In practice a large amount of negative reactivity is usually provided for shutdown safety. To move rods too slowly in this subcritical or reactor start-up condition is very time consuming, but for operational adjustments of a critical reactor slow movement is a must.

2. The rods must move rapidly with at least a net acceleration of gravity to reduce reactivity and stop the reaction when necessary. Because of friction and the possibility of sticking, some kind of spring is usually provided to make this rapid movement very certain. This rapid reactivity reduction process is referred to frequently as "reactor scram" or just "scram," probably because of the nature of the catastrophe it is supposed to prevent.

3. Rods should remain stationary at any position to which they are moved by the mechanism. They should not drift or vibrate to any extent under the effect of mechanical forces acting on them due to the circulation of coolant in the reactor.

4. An accurate measurement of position should be possible at a remote point convenient for the operator. The accuracy here is so dependent upon the reactor purpose that it would be difficult to give a general figure. Perhaps for the power reactors being designed today, 0.1 inch would be satisfactory. Experimental reactors require position measurement of very much greater accuracy.

To fill these needs, the designers have used the familiar rack and pinion drives or lead screws and nuts for most reactors. Ball nut jacks have proved to be especially suitable for rod drive mechanisms. By using electromagnetic clutches or holding electromagnets, fast scram motion is obtained releasing the rods to fall under the effect of gravity or other stored energy source. Meeting the drive require-

ments is not difficult in low-pressure systems where the mechanism runs in air or an inert atmosphere such as helium gas which is usually applied on heavy-water reactors.

At present, the art is moving rapidly into the field of reactors pressurized to several hundred pounds per square inch. In a light-water pressurized system for a central station plant, a good rotating or sliding seal with controlled leakage will satisfactorily admit rods through the pressure shell. However, economy studies on large central-station plants point toward the use of heavy water as a cooling and moderating medium. Using seals here with any leakage at all could prove costly and seriously affect plant economy. To make these plants attractive, a low-cost simple mechanism is needed which will operate inside of the pressure shell and meet the foregoing four criteria.

On first look, the tendency is to minimize this problem, but remember that such a device should be as rugged and maintenance-free as possible because removing it could be a difficult and costly operation. The mechanisms' operating rods used on high-power reactors tend to become very radioactive. A man might not be able to work at the removal of a faulty drive for longer than 15 minutes before he receives his weekly radiation allowance of about 400 milliroentgen. Here certainly is a place for real combined electrical and mechanical engineering ingenuity which would facilitate future reactor construction.

Examples of Engineering Applications on IBM Digital Computers

I. C. LIGGETT

Three typical engineering problems solved by the IBM (International Business Machines Corporation) Scientific Computation Laboratory are given. They demonstrate approaches that might be used in the solution of many similar problems. The use of computers can lead to different approaches to problems thus yielding valuable results more quickly and economically.

THE CIRCUIT shown in Fig. 1 is a device for electrically checking the occurance of 1 to 60 events. Sixty circuits are paralleled across a bridge circuit from C to M and may assume four conditions when the device is used. Each upper relay is closed by a given instruction and the corresponding lower relay is closed by the execution of that instruction. These have been grouped in Fig. 1 and labelled W, X, Y, and Z where each represents conditions as follows:

W—Number of circuits which agree.
X—Number of circuits which disagree, lower side open.
Y—Number of circuits which disagree, upper side open.
Z—Number of circuits which are not used.

$$W+X+Y+Z=60 \text{ circuits}$$

Conditions W and Z are correct; conditions X and Y indicate errors. As long as conditions W and Z occur, without the presence of X or Y, the voltage across points A and B should be below a fixed value, K. If one or more errors occur, making some X and Y circuits, the voltage across A and B should be above the fixed value K. This fact can then be reliably recognized and an error indicated.

In order to set the tolerance limits on the resistors and diodes for proper operation, it is necessary to calculate voltage AB for a reasonable number of combinations of the four types of circuits. Forty combinations of circuits W, X, Y, and Z were chosen to represent all the critical and typical cases. The problem involves the solution of five linear equations which are obtained by writing Kirchhoff's current equations for the nodal points A, B, D, E, and F. Another equation can be written at point G but since the line current is not required, one equation was eliminated. The equations are as follows:

$$\text{(A)}\quad \frac{V_a-0}{R_2}+\frac{V_a-V_c}{R_1}+\frac{Z(V_a-V_b)}{2D_b}+\frac{X(V_a-V_d)}{D_b}+\frac{Y(V_a-V_e)}{D_f}+\frac{W(V_a-V_f)}{D_b}=0$$

$$\text{(B)}\quad \frac{V_b-0}{R_4}+\frac{W(V_b-V_f)}{D_b}+\frac{Y(V_b-V_e)}{D_b}+\frac{X(V_b-V_d)}{D_f}+\frac{Z(V_b-V_a)}{2D_b}+\frac{V_b-V_c}{R_3}=0$$

$$\text{(D)}\quad \frac{X(V_d-V_b)}{D_f}+\frac{X(V_d-V_c)}{R_7}+\frac{X(V_d-V_a)}{D_b}=0$$

$$\text{(E)}\quad \frac{Y(V_e-0)}{R_8}+\frac{Y(V_e-V_b)}{D_b}+\frac{Y(V_e-V_a)}{D_f}=0$$

$$\text{(F)}\quad \frac{W(V_f-0)}{R_6}+\frac{W(V_f-V_a)}{D_b}+\frac{W(V_f-V_b)}{D_b}+\frac{W(V_f-V_c)}{R_5}=0$$

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where D_f is the resistance of a dioide when current is flowing in the conductive direction, and D_b is the resistance of a diode when current is flowing in the blocking direction.

A line voltage V_c was assumed and the other voltages solved in terms of it. The five equations were solved simultaneously on the CPC (Card Programmed Calculator) using the "Gauss-Seidel" iterative method of successive approximations. This method is particularly good for this type of problem because the answers to all sets are in the same range. On the average, ten iterations are sufficient for convergence. A total of 165 solutions were obtained in 8 hours of machine time or an average of 3 minutes per case. The total planning and coding time was 2 days.

The results of this problem revealed that:

1. Commercial diodes could be used with realistic specifications.
2. Ten-per-cent tolerance for the resistors gave satisfactory operation under the worst conditions of tolerance build-up. It was formerly thought that 5-per-cent resistors would be required.
3. The circuit performs as predicted.

This problem shows how a mathematical analysis can determine the optimum electrical design which will result in saving the expense of building and testing several models.

POTENTIAL DISTRIBUTION IN A GAS TUBE

THE potential distribution in a gas tube can be expressed by a well-known mathematical equation. A cross section of a typical tube with a grid chart superimposed on it is shown in Fig. 2. In order to graph equal potential lines, the potential at a large number of grid points must be calculated.

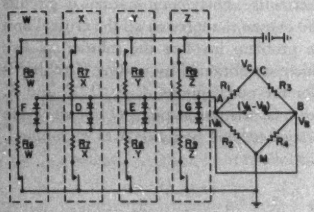


Fig. 1. Electric coincidence circuit

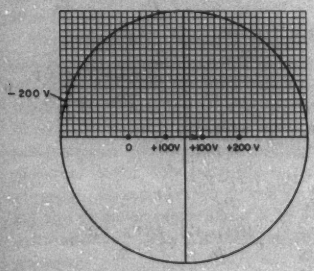


Fig. 2. Gas tube cross section with numerical mesh

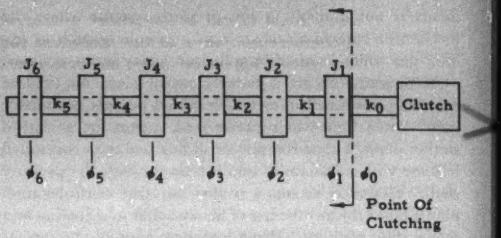


Fig. 3. Torsional vibration schematic:

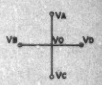
$J_1, J_2, \ldots J_6$—Mass moments of inertia of the six feed roll components; $\phi_1, \phi_2, \ldots \phi_6$—Angular displacements of the six feed rolls with reference to the clutch point ϕ_0; $k_1, k_2, \ldots k_5$—Torsional stiffnesses of the sections of the shaft between feed rolls; k_0—The stiffness or "spring rate" of the clutch combined with the first section of the shaft

The potential in a region not containing a source or a sink satisfies LaPlace's Equation:

$$\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}=0$$

If the grid spacing is uniform, LaPlace's Equation can be replaced by the following set of approximating difference equations:

$$V_0=\frac{V_a+V_b+V_c+V_d}{4}$$



Because of symmetry, half of the area is considered in the problem. A 40 by 20 grid was arranged so that intersections occurred at the four potential points inside the tube. The internal voltages were assumed to be point sources for ease of solution. The 800 grid points were assigned 800 storage locations with convenient location numbers to simplify the program. The machine calculated the outside boundary by determining the mesh-point distance from the center. This distance was calculated for each point, and the first point in each row to lie within a circle of radius $R+\Delta X/2$ (where R is the radius of the tube and ΔX is the mesh increment) was stored as the starting point. The calculation was done only once to establish start and stop positions for each row. The following programs were then written:

1. Solution of a general point.
2. Alteration program to apply to all points of interest.
3. End of iteration routine.
4. Special subroutines for the center row.
5. Test for convergence is $\Sigma/\Delta V/$ for all points for each iteration.
6. Use standard load and punch routine.

The problem was solved by the first engineering model of the IBM *650* magnetic drum calculator because the type and size of the problem is well suited to this machine. The entire program can be written by an experienced programmer in 2 hours with less than 200 instructions. The solution time is less than 4 minutes per iteration of the entire matrix. Eighty iterations produced convergence starting with zeros as first guesses for the unknown points and the total running

time for the solution is about 5 hours.

The problem is easily adaptable to this machine because of the ability to put all the mesh-point values and the instructions into storage. The ability of the machine to alter its own program makes the program short and easy to write. Many applications, including the field of ordinary and partial differential equations, will be very practical on the IBM *650* magnetic drum calculator.

TORSIONAL VIBRATION: OF MULTIMASS SYSTEMS

Problems in torsional vibrations quite frequently arise in engineering. As an example, consider a drive shaft rotating at constant speed and suddenly stopped by a clutch. Each gear, cam, or roll on this shaft constitutes a concentrated mass having a high rotational inertia, and this condition gives rise to torsional vibrations. Questions the designer might ask are:

1. What is the maximum displacement of any or all of the vibrating masses?
2. How soon after clutching does each or any mass reach its maximum displacement?
3. The sudden stop obviously causes high torsional stresses. What is the maximum stress in the shaft and/or the clutch?
4. How much "spring" can be built into the mechanism to reduce the maximum stress and still not exceed the maximum desirable displacement?
5. How are the deflections and stresses affected by varying parameters:
   (a) Shaft speeds.
   (b) Stiffness of the shaft and clutch.
   (c) Inertias of the mechanism.
   (d) Damping (friction).
   (e) Backlash in the gears.

These might very well be vitally important questions. Investigation could, for example, show that an excessive displacement adversely affects card registration, or that a part of the mechanism is being stressed above allowable limits. However, the solution of torsional problems by direct analytical methods is often difficult and frequently impossible.

The IBM Scientific Computation Laboratory has used a simple approach to solve a torsional problem illustrated in Fig. 3. An initial assumption was made that for a small interval of time of about 0.1 millisecond, the torque being applied to each mass is constant. By calculating the motion of each mass, using constant acceleration formulas with whatever velocity and displacement each had at the beginning of the interval, new positions at the end of each interval can be determined. Each mass moves independently until the end of each interval at which time the acceleration is determined from the relative position of all masses. The equation of motion of each body is of the following form:

$$\Sigma \text{ Torque} = J\phi \text{ For body } \#4 \quad (\phi_3 - \phi_4)k_4 - (\phi_4 - \phi_5)k_5 = J_4\phi_4$$

Neglecting friction it is seen that the acceleration of each mass is directly obtainable from the relative position of the two adjacent masses.

This process is actually similar to solving six simultaneous second order differential equations using a simple difference system. It sometimes is easier to think in terms of the physical situation rather than the mathematics involved.

A plot of the results is shown in Fig. 4 for a 6-mass system neglecting friction and discontinuities. All six masses are plotted showing the angular displacement in radians versus time in milliseconds. The period can be taken from the graph. The plot was obtained from a set of tabulated results which give displacement, velocity, and acceleration data for all six masses at each tenth of a millisecond. The maximum difference between displacements of adjacent bodies can be found automatically by the machine to determine maximum stresses.

This problem was planned, coded, and checked out in 4 hours on the CPC and the running time for the solution was $1^1/_2$ hours.

The advantage of this method is seen when friction and discontinuities such as backlash are included in the problem. These things may be included with little difficulty in this type of solution, whereas the analytic solution becomes very cumbersome. The physical situation is actually being simulated with a simple approach which requires a large amount of calculation. With a suitable digital computing machine, this type of solution becomes very practical and realistic.

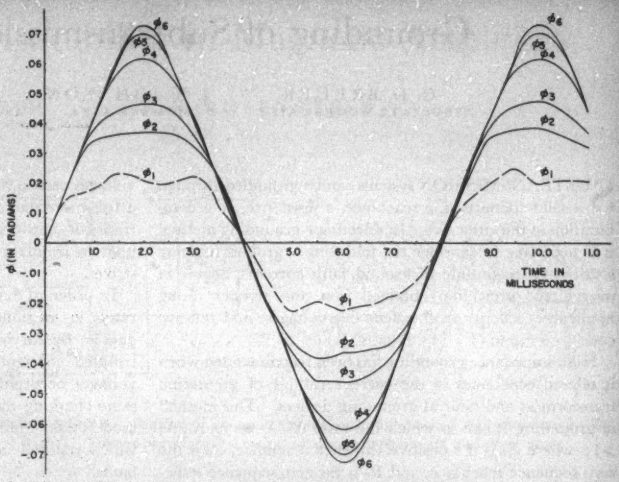


Fig. 4. Torsional vibration: angular displacement versus time for a 6-mass system

Grounding of Subtransmission Systems

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SUBTRANSMISSION systems can be grounded through a solid connection, a reactance, a resistance, or a combination of the latter two. In selecting a grounding method it is necessary to consider the following: ground relaying sensitivity, magnitude of ground fault currents, degree of overvoltage protection obtained from the arrester rating applicable, severity of transient overvoltages, and relative cost.

High-impedance grounding has been recommended when it offered economies in the current ratings of grounding transformers and neutral grounding devices. This method of grounding is one in which the ratio $X_0/X_1>3$ or $R_0/X_1>1$; where X_1 is the positive sequence reactance, Z_0 is the zero sequence reactance, and R_0 is the zero sequence resistance. High-impedance grounding has involved problems of transient overvoltages which may be initiated by restriking in a circuit breaker upon interruption of line-to-ground faults or by faults in solid dielectrics. Previous studies in the field have indicated that multiple restriking and consequent cumulative build-up of transient overvoltage can be eliminated provided the ratio X_0/X_1 in the system is less than 10. Another suggested criterion to limit transient overvoltages is that the ratio R_0/X_0 should be 2 or greater without regard to the ratio X_0/X_1.

This digest evaluates the grounding criterion for high-impedance grounding by comparing previously used criteria with results of a study on systems in miniature.

A system having $X_0/X_1\leqq 3$ and $R_0/Z_1\leqq 1$ is defined as effectively grounded. It has line-to-ground fault currents, 60 per cent or more of 3-phase fault currents, and readily permits selective ground relaying. With this grounding, transient overvoltages when interrupting ground fault currents are avoided. It also permits use of the grounded neutral rating of lightning arrester, which provides the best margin of protection from lightning. The effectively grounded system, however, requires a grounding transformer with a higher current rating than would be required with high-impedance grounding.

As the reactance ratio is increased up to a ratio of $X_0/X_1=10$ the ground fault current is reduced to 25 per cent or more of 3-phase values, still permitting selective relaying. The ungrounded neutral lightning arrester must be applied to this system. However, the possibility of transient overvoltages caused by phenomena such as circuit breaker restriking when interrupting line-to-ground faults are avoided.

With a reactance ratio $X_0/X_1>10$, there arise questions of the occurrence of transient overvoltages and the feasibility of selective ground relaying. To study transient overvoltages caused by restriking in a circuit breaker switching a line-to-ground fault, various systems were set up on the transient network analyzer. A synchronous switch was used to simulate a circuit breaker opening with two restrikes.

In order to determine the circuit conditions that would result in maximum voltages, all conditions were investigated. By varying the number and lengths of line of distributed constant models, it was found that the highest voltages occurred when a lumped capacitance with the same charging reactive kilovolt-amperes as the distributed models was connected. The location of the fault was varied which resulted in the highest voltages occurring for bus faults.

The closing of the synchronous switch applied the fault and it was held closed until the transient caused by fault application had decayed, which is equivalent to a relay plus clearing time of 5 cycles. This preliminary study indicated that the data obtained were as severe as could be expected in practice.

The results of the study presented in curves showing maximum voltage as a function of system parameters indicate:

1. For systems with $R_0/X_0>2$, the transient voltages resulting from restriking in a breaker switching a ground fault will not exceed the line of approximate switching surge sparkover voltage of 100-per-cent arresters, regardless of X_0/X_1.
2. Where $R_0/X_0<2$, voltages of arrester sparkover can be obtained when the two restrikes are initiated to produce maximum overvoltage.

Further checks on the data indicated that for $R_0/X_0>2$, the voltage build-up obtained with three restrikes was no greater than resulted from two restrikes. The effect of faster switching times was also considered by interrupting the fault at the first current zero and for $R_0/X_0>2$, the transient overvoltages resulting from three restrikes were less than the switching surge sparkover of 100-per-cent arresters. Therefore, the conclusions reached from the original data are not altered.

In the application of grounding transformers, a ratio of $X_0/X_1<10$ results in ground fault currents, 25 per cent or more of 3-phase fault currents. As these currents are larger than necessary for selective ground relaying, higher ratios of X_0/X_1 can be used to yield lower ground fault currents as well as attractive economies in grounding equipment. To use ratios of $X_0/X_1>10$ two approaches are suggested:

1. The limitation of transient overvoltages to values below arrester sparkover by use of the criterion $R_0/X_0>2$.
2. Grounding with negligible R_0 and relying on arresters to limit transient overvoltages if they should occur.

Digest of paper 54-360, "Grounding of Subtransmission Systems," recommended by the AIEE Committee on Protective Devices and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Published in AIEE *Transactions*, vol. 73, pt. III, 1954 (Jan. 1955 section), pp. 1580–5.

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Inductive Load Instability in Magnetic Amplifiers

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A. B. ROSENSTEIN

LIMITATIONS in the design of high-performance magnetic amplifiers have often been attributed to imperfections in the magnetic amplifier core and rectifier characteristics. Yet, in some instances, the useful operation of the magnetic amplifier has been the result of the existence of these same so-called imperfections. Evaluation and understanding of the parameters of the material imperfections can point the way toward utilization of the characteristics that have been regarded as the limiting factors in the amplifier performance. As an example, rectifier capacitance and leakage current tend to reduce over-all amplifier gain. At the same time, inductive loading of some circuits creates additional positive feedback and instability. By adjusting the negative feedback caused by rectifier leakage current and capacitance, these inductively loaded circuits can be made to give stable high-gain performance.

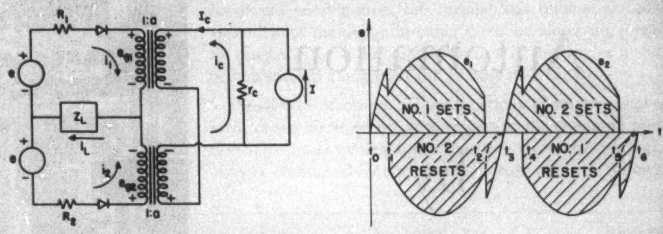


Fig. 1 (left). Schematic diagram of magnetic amplifier circuit showing sign convention. Fig. 2 (right). Voltage waveforms showing maximum possible set and reset areas

The mechanism of the instability caused by inductive loading of the full-wave self-saturating magnetic amplifier can be explained briefly from Figs. 1 and 2. From t_0 to t_3, reactor 1 sets and reactor 2 resets. At t_2, reactor 1 saturates, and current i_1 flows in loop 1 in the interval t_2 to t_4. The interval from t_3, when $e_1=0$, to t_4 is the overlap or commutation period. As long as i_1 flows, reactor 1 is considered a short circuit, and consequently double set voltage is applied to reactor 2 during the commutation period. From t_4 to t_5, reactor 2 receives normal set volt-seconds, while reactor 1 receives equal reset volt-seconds. At t_5 reactor 2 saturates and fires.

Reactor 2 may now be considered a short circuit and double voltage becomes available to reset reactor 1. The induced voltage in the control winding of reactor 1 creates a circulating current i_c such that the reflected voltage drop $i_c r_c$ is equal to e_1+e_2. If it is assumed the rectifiers have negligible capacitance and infinite reverse resistance, the reset voltage follows the dashed line from t_5 to t_6 instead of the double voltage line. For sufficiently small values of r_c, the double set (commutating) period will cause the reset volt-second area for a reactor to become less than its preceding set volt-second area. Since the following set volt-second area must equal the reset area, the firing angle will advance and the magnetic amplifier will be unstable.

The instability can be attributed to the inductive load which adds set voltage to one reactor while subtracting reset voltage from the other during the commutating period, and by a small value of r_c which restricts the available double reset interval. With a large value of r_c, the magnetic amplifier is stable. It should be noted that with higher quality core materials (i.e. steeper and narrower B-H curve), the energy stored in the core is smaller, the magnetizing current is smaller, and consequently the amplifier again becomes unstable unless r_c is increased. With perfect rectifiers and high-quality core materials, the self-saturating full-wave magnetic amplifier is inherently unstable under inductive loading.

Anything that will reduce the inverse impedance of the rectifier will provide additional negative feedback and improve stability. The commercial rectifier cells have less than infinite reverse resistance and selenium cells have surprisingly high capacitance. Using small angle theory, the following equations for the minimum stable firing angle θ have been developed for quality core materials having nearly zero magnetizing current. For negligible rectifier capacitance

$$\theta=\frac{3R_bQ}{4(R_c+R_b)} \tag{1}$$

where

R_c = control circuit resistance reflected to load side
R_b = reverse rectifier resistance
$Q=\omega L/R$
R = the sum of load, winding, source, and forward rectifier resistances

For appreciable rectifier capacitance C and small forward rectifier resistance, the critical value of control resistance for border-line stability becomes

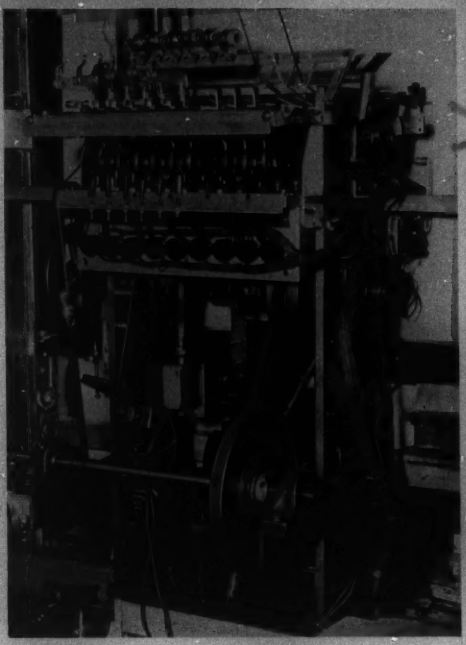
$$R_c=\frac{Q}{2\omega C} \tag{2}$$

Digest of paper 55-21, "Inductive Load Instability in Magnetic Amplifiers," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

H. I. Leon and **A. B. Rosenstein** are both with the University of California, Los Angeles, Calif.

The research was sponsored by the Aviation Ordnance Department, U. S. Naval Ordnance Test Station, Inyokern, China Lake, Calif.

Textile Automation by Signal Control



LOUIS CASPER
MEMBER AIEE

Experimental operation of a prototype textile automation machine utilizing a 5-unit telegraph system has shown that the design has valid justification beyond that of availability. Its adaptability to this application is clearly indicated.

IN the field of electric control of automatized machines, much effort is being directed towards bringing together the thinking of engineers in the mechanical field of design[1] and in the electrical field of signal communication.[2] One of the problems dictates the evolution of a common vocabulary. Closely related to it is the matter of making available to engineers in each of the two fields the body of knowledge already available in the other. To these twin problems, by means of a specific typical situation, this article is addressed.

The experimental development to be described looks to the general control of textile machinery by means of ordinary 5-unit binary-coded paper tape and standard associated printing-telegraph apparatus,[3] applied with minor alterations. A successful experimental model of an embroidery machine has been found capable of responding to tape control at the average rate of 500 stitches per needle-minute—the color, direction, and length of each individual stitch having been put under anticipatory control during the brief time interval separating each stitch from its predecessor. The development also contributes by specific example to the notion of the automatic factory in which unit machines may be ganged together and remotely controlled for purposes of labor economy and maximum machine-hour utilization.

Objectives. On account of the fact that in this adaptation, as in predecessor typesetting-machine[4] and computer[5] applications, the control equipment has been lifted bodily out of a telegraphic environment, the remoteness of the control of single or ganged machines may be anywhere—at the units themselves, in one corner of the factory workroom, floors below, or from an office or studio miles away. The last-mentioned capability is derived from the reproducibility of 5-unit telegraph signals by standard methods of tape reperforation, now technically feasible throughout the world by wire, cable, and radio transmission.

Granted that extreme remoteness of control, however practicable, may for the moment be brushed aside by today's textile practitioners as being somewhat in the realm of the future, yet flexible electric coupling between the needle-shuttle fabric-feed structures of a textile machine and their controls remains a useful present design objective. So, too, remains the ideal of electrically switching together several or many identical machines for common simultaneous operation. Such switching holds promise of emancipating

Revised text of paper 55-174, "Textile Automation by Signal Control," recommended by the AIEE Committee on Telegraph Systems and approved by AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955.

Louis Casper, retired member of the Western Union Telegraph Company staff, is vice-president of the Electrotext Corporation, New York, N. Y.

The author wishes to express appreciation to J. J. Fossaner, R. E. Benedict, and L. D. W. Casper for design and construction work in connection with the development.

the textile manufacturer from the burden of providing each one of a battery of machines with individual card or link-pin controls and from his present inability quickly to deploy his facilities to meet an influx of orders with their urgency priorities.

THE TEXTILE MACHINE APPROACH

Even in their modern forms, both weaving looms and embroidery machines tend to be heavy, ponderous, and inflexible, due to the rigidity of their systems of control pins, rods, gears, cams, and pantographs, which must be mechanically coupled to the functional parts of the machines. When the controls are electric, a relatively few solenoids, interposed in the gears and shafting between driving motors and the actuated needles and fabrics, suffice to impart to the latter all necessary movements in lieu of mechanical ties. The sequencing of the solenoids is adaptable to reliable methods of electric machine-switching, with its advantages of flexibility and speed.

Embroidery in Color. Textile embroidery usually uses a woven fabric as a base upon which the design is added as an embellishment. The machine resembles the familiar sewing machine in its needle movement. The fabric, or "goods," held in vertical movable frames and receiving the embroidery design, must be positively positioned in sequential presentation to horizontal needles and their associated shuttles, loaded with colored or textured thread or yarn.

In the experimental machine, provision has been made for the initial use of ten different colors of thread. A compact row of ten horizontal needles in the z axis, backed up by their corresponding ten shuttles, (the operation of which can be separately selected for control) are rack powered by a single drive, designed for a $2^1/_2$-inch needle throw.

Frame Controls. In a vertical plane of the x and y axes, interposed between the horizontal row of needles in front and the row of shuttles in back, the piece or roll of base fabric upon which the embroidered design is to be created, is affixed semipermanently to a pair of lead screw-driven frames running on guide rollers. The outer frame moves horizontally, to and fro, along the x co-ordinate in controlled steps equal to the chosen length of stitches; and carries the vertical frame with its drive motor and lead screw. The counterbalanced inner frame moves vertically, up or down, along the y co-ordinate in stitch-length steps.

The experimental machine with a horizontal row of ten needles loaded with varicolored thread latched for electric release for stitching operation is shown in the title picture. The corresponding shuttle structure is mounted behind the material stretched on a vertical frame.

Control Boxes. The codification of frame controls to accomplish stitching in 16 directions is simplified by the mechanical design of the power trains to the lead screws. Control boxes, of identical pattern, are interposed between horizontal and vertical frame drive motors and their respective lead screws. In each control box are clutches and gear trains which perform two functions in response to electromagnetic controls: the lead screws' progression, or the reversal thereof is controlled by two clutch trip magnets, either one or the other being code selected for each frame movement; the lead screws' progression can be halved or restored to normal by two shift solenoids which are code-selected to couple together, until reshifted, two pairs of matched gears in tooth ratios of two-to-one.

By these means, a codified control tape advances the frames one step at a time in either direction, horizontally and/or vertically, in full- or half-stitch increments, as desired. In combination, the vertical and horizontal codes also advance the design in either direction along any one of six diagonals by simultaneous shifting of the frames in full or half stitches along both the x and y co-ordinates.

Direction of Movement. The directions of relative movement of any fixed needle with respect to the changing position of the inner vertical frame may be conveniently thought of as 16 compass directions from a datum point, as follows:

Direction	Vertical Movement	Horizontal Movement
Idle	None	None
N	Up, full	None
NNE	Up, full	Right, half
NE	Up, full	Right, full
ENE	Up, half	Right, full
E	None	Right, full
ESE	Down, half	Right, full
And so on	Up or down	Right or left
	Full or half	Full or half

Unison Positioning. One or the other of the end needles must have a home position, say at a corner of the design, from which it will be stepped, without stitches, to the point where the design will be begun. Area limit switches guarding the four design borders facilitate initial homing in a corner: The insertion in the coded tape of more than enough control steps towards the edges to pass the two border limit switches defining a corner will place a gang of machines in unison positions for commencing a new design, no matter what their respective locations may have been after previous use.

Needle Controls. All ten needles are normally retracted and latched in an inoperative position until released individually by a coded signal. When all needles are latched, the goods can be stepped by operation of the frames into position under the needle next to be released by the code-tape control. When so released the needle and its associated shuttle movement will produce one stitch.

Severance of Threads. The needle and shuttle threads are, in response to the tape control signal, severed close to the fabric on both sides of the workpiece.

Color Changes. Severance of needle and shuttle threads without human intervention, and without loss of time beyond that of a single stitch, facilitates ready changes of color in design, since to resume stitching it is only necessary to serve the work horizontally (without stitching) to a needle shuttle loaded with thread of a proper color, and then to release it.

Position Changes. The frames will transfer also, in effect, a needle, after retraction and severance of thread, from its former to a desired new position anywhere on the workpiece.

Types of Stitch. The prototype machine uses a lock-stitch reciprocating shuttle which, as in the familiar home sewing machine, locks, with a second thread, the loop introduced through the goods by the needle and prevents its withdrawal with the needle.

It is beyond the province of this article to list the many textile variants for the insertion of thread or yarn through material which may vary from fine silk to heavy carpeting.

Materials. Thread usable in embroidery machines of this type may be of any standard weight or gauge; of synthetics, silk, cotton, wool, or mixtures, from single filaments to heavy multiple-twist. The backing of embroidery may range all the way from flimsy gauze to burlap and canvas, and in shape from squares for belts to made-up garments.

Length of Stitch. As noted previously, the length of stitch is under continuous two-to-one codification control in the machine. In addition, it is also adjustable, by presetting, from 4 to 32 stitches per linear inch.

THE PRINTING TELEGRAPH APPROACH

FIVE levers, each capable of taking up either of two positions, can determine 2^5, or 32, different code-control combinations. These 32 are sufficient to select and actuate any one of a combination of 26 different needles and associated shuttles; to retract and re-latch them; to sever all threads; and to halve the normal length of stitches.

There is a striking similarity between such control requirements and those met by a conventional teletypewriter. In the latter case, the same 32 code combinations are available; there are 26 different alphabetic type-bars to be actuated, one at a time; and the remaining codes are used to control the movement of the typewriter carriage, and shifts between upper and lower cases.

Analogies. It was the promise held out by the similarity of the telegraph communication art to the textile control problem that first suggested the probability that available telegraph equipment, with only minor adaptive changes, might be applied directly to the control of embroidery machines.

In both cases, for example, long 5-unit tapes can be code punched on keyboards (the telegraph *perforator*); they can be stepped along by means of punched-out feed holes, one control code (the telegraphic *letter*) at a time, scrutinized by 5 transverse ganged sensing levers (the telegraph *transmitters'* tongues), bearing electric contacts for *making* circuits (telegraphic *marking*) and *breaking* them (telegraphic *spacing* signals).

The Distributor. In action, telegraphic distributors are not unlike those of automotive ignition, with revolving arms sweeping sequential segments. In telegraphy, where miles separate perforator keyboards from terminating teleprinters, two additional commutator segments must be added to the five signalling segments in order to maintain necessary start-stop synchronism between the distributor brushes at the sending and receiving ends of the wire. These extra two segments (total 7), are usefully retained in textile control to schedule and synchronize the related electrical events which must precisely dovetail, and to shift control from the 7-segment signalling "channel" just described, hereafter called *B* channel, to a similarly contrived *A* channel having 7 more segments; hence, a total of 14 segments during each revolution of the brushes before the entire cycle repeats. In telegraphy, the *A* and *B* channels are alike in function as well as in arrangement, and they transmit two different telegrams. In the embroidery machine, the two channels are different in their functioning: *A* channel governs the operation of the frames; *B* channel governs the operation of the needles.

Two-Channel Operation. The necessity for a second channel in textile operation arises partly from the fact that the *B* channel's 32 code combinations have been exhausted in controlling the needles; and beyond these 32, there exists a further requirement for codes to position the frames carrying the fabric. Neglecting variable lengths of stitch, which have already been provided for on the *B* channel, frame movements require nine additional code combinations (including one for no frame movement). Another channel, *A*, is therefore required. Since three levers (affording $2^3 = 8$ codes) are too few, a minimum of four levers is required for the *A* channel. It simplifies design to employ five levers instead of four, making *A* channel identical in form (though not in its functioning) with *B* channel, and making it possible to use existing 2-channel start-stop telegraph apparatus with little change.

There is another reason why the 2-channel telegraph adaptation proved attractive in textile control. The needles must be idle while the goods are moved, and the fabric must be held steady while the needles pierce it and are withdrawn. Alternate (that is, 2-channel) operation satisfies these requirements. As the distributor brushes sweep the first 7 segments, the frames are moved to a new position. As the brushes sweep the second 7 segments, the needles and shuttles accomplish one stitch.

At only one point has it seemed expedient to have the textile application depart from 2-channel telegraph practice. In the latter, telegrams on *A* and *B* channels are independently perforated in separate tapes by separate operators and are fed into separate transmitters. In textile control, it was evident that a single tape, fed through a single transmitter, was mandatory to preserve co-ordination between frames and needles. Therefore, alternate switching of the tape codes takes place—first frame function, then needle function; frame, then needle—*A* channel, then *B* channel—and so on as the tape progresses through the transmitter, center-hole by center-hole. There are therefore two center-holes per stitch; two equal control-time intervals per stitch (7 segments, 5 code units); and two coded controls (frame, needles) per stitch.

INTEGRATION OF FUNCTIONS AND CONTROLS

Circuitry. Impulses through segments on the frame-control channel actuate directly the trip-magnets in the lead-screw control gear trains. Impulses through segments on the needle-shuttle selection and control channel actuate a series of five multipoint single-pole double-throw relays arranged in a fan- or tree-circuit in such a way as to find 16 different paths for applied potential to take to trip, retract, and otherwise to control ten needles. In the experimental model the first of the five single-pole double-throw relays

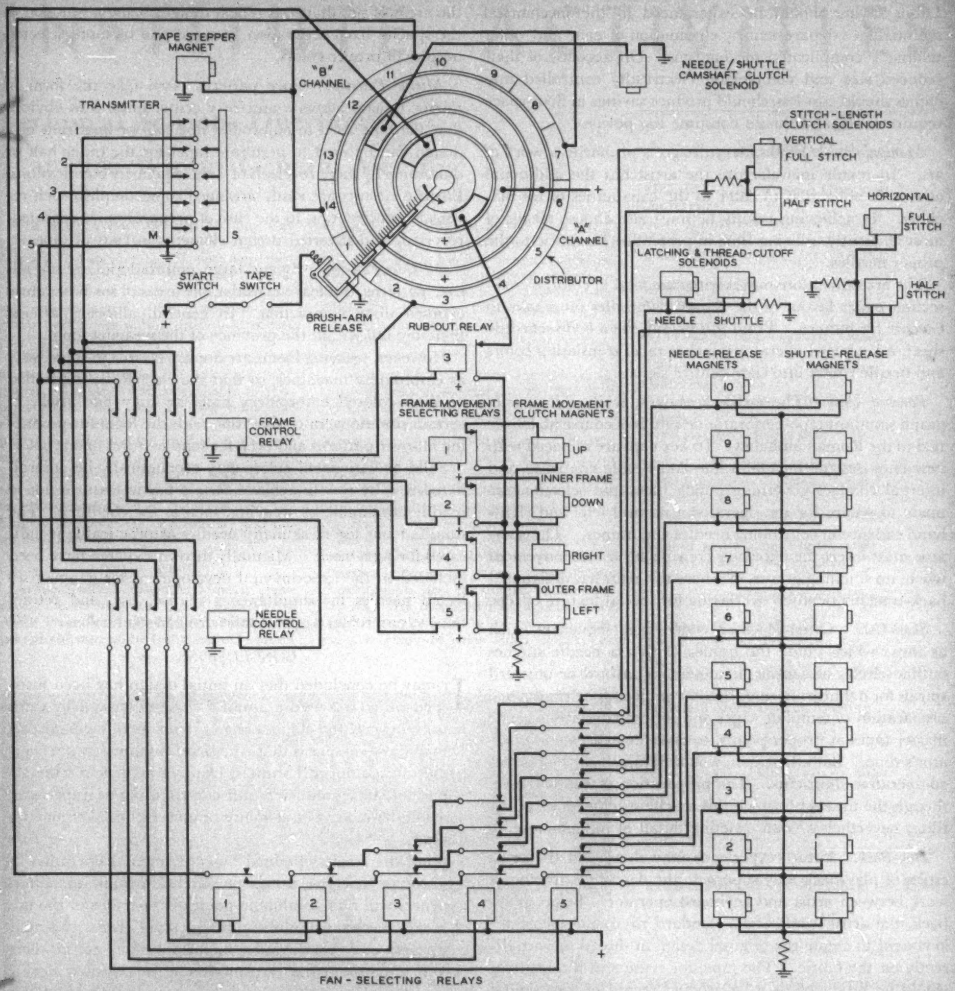


Fig. 1. Schematic showing control of embroidery machine by adapted telegraph transmitter and distributor. Twice during each revolution of the brush arm, the tape stepper magnet presents fresh coded intelligence to the transmitter sensing pins and to the frame and needle control relay contacts. As the latter two relays are successively actuated, the codes are transferred in turn to the frame movement controls and, through the fan-relay circuit, to the needle-shuttle controls

has one pole idle; if utilized, the number of paths through the circuit could be increased by 16, and the total number of needles (and thread color-changes) increased to 26.

The foregoing explanation will be aided by reference to the schematic diagram of Fig. 1.

Ganged Machines. A cord patching and switching panel is provided, so that any one transmitter-distributor, out of a number of such, may be manually plugged up to any selected one or a multiplicity of embroidery machines, thus affording production flexibility and capacity to meet manufacturing demands.

Maintenance Costs. It is a feature of electric, as opposed to mechanical, control that the patching board, transmitters, distributors, and switching may be concentrated in a lint-free location as remote as necessary from the machines proper. Interpretive neon lamps introduced into the circuitry facilitate electrical servicing of a battery of machines; and machine concentration reduces testing and regulating labor requirements.

Since the electric equipment has seen long service in the telegraphic art, low costs for electrical maintenance may be reliably forecast, even in advance of factory application.

Labor saving should be experienced in the mechanical maintenance department by elimination of cam and other relatively complicated mechanisms. On account of their reduced size and complexity, electrically controlled machines should cost less, should produce savings in floor-space requirements, and should consume less power.

Manipulation. Embroidery design is primarily a work of art. In textile manufacture the artist has the additional economic obligation to cater to the capabilities of his machine. In achieving beauty he must also choose means of most efficiently utilizing time in presenting his fabric to the proper needles.

The artist therefore makes with care, and in color, a cross-section paper layout of the routes his needles must take to execute his pattern. From this layout, via a code-schedule sheet, a keyboard operator punches tape, translating colors and needle routes into code control signals.

Punched Tape. The textile keyboard, while still of telegraph standard tape-perforator design, is of course no longer tied to the Roman alphabet. Its key caps are replaced with new ones designating the frame and needle controls; and internal changes governing punch block pin selection are made to secure for the operator a natural left- and right-hand cadence in controlling needles and frames. The operator must insert the necessary controls for frame movement where no stitching occurs, or where the artist has designated back-tracking or stitch overlaying for special texture effects.

Short-Cuts. Often-repeated coded tape sequences, such as those which guide the frames so that a needle stitches outline circles of various diameters, or inward or outward spirals for delineating rings become subjects for the advance preparation of template tapes and for their insertion in the master tapes at proper points, to save the artist's and operator's time. Both these men would naturally develop other co-operative short-cuts. The preparation of control tape, though the means by which this machine achieves its versatility, nevertheless is an exacting detail of manufacture.

Play-Back. Future experience may show that the principles of play-back may supersede the described division of work between artist and keyboard operator. Before play-back, the artist would use a standard rhythmic teleprinter keyboard to create the original design in thread or yarn directly on the fabric. The tape, for reuse and duplication, would be produced as a by-product record of his original design.

Duplication of Tapes. The perforator is capable of producing more than one tape at a time and, by means of reperforators, a tape may be used to reproduce any number of copies of itself economically. Paper tape may be run through transmitters scores of times before wearing out. Parchment tape is available having life running into hundreds of occasions of reuse.

Multiple Patterns. In certain pattern designs advantage is taken of the needle flexibility afforded by code selection to select more than one needle for simultaneous operation. This means that the same design, in the same or different colors, will be repeated in different areas of the fabric during a single series of movements of the frames, the disposition of the areas of simultaneous repeat designs being a function of the spacial fixed separation between two or more selected needles of proper colors.

Mirror Patterns. Since patterns often take the form of mirror images across x and/or y center-lines, it is obvious that the tape used to embroider one half or quadrant of a design can be used to perforate tapes for the other half or quadrants by mere reversals of x and y polarity codifications. Electric circuits are easily arranged to accomplish such reversals, contributing to the ease of preparation of repeated, reversed, and inverted design elements in control tapes.

All-Over Patterns. By and large, embroideries are not all-over patterns, but leave considerable areas of the base fabric exposed upon completion. In general, all-over patterns therefore fall within the province of the weaving loom.

However, weaving looms are not as versatile in some ways as embroidery machines, so that the electrically controlled multiple-colored embroidery machine may find itself, in certain situations, in competition with the loom for producing all-over patterns and even for solid textures of one color.

Solid or variegated colors may economically be embroidered row by row to achieve certain fabric textures not so readily obtainable by weaving, such as the chenilles. The simultaneous use of as many needles as practicable is indicated for such work. Manually thrown switches have been included in the experimental development for ganging selected needles for simultaneous release, use, and retraction, to embroider areas of solid or near-solid colors.

CONCLUSIONS

It may be concluded that an initial design has been justified which has used a 5-unit 2-channel system for valid reasons beyond the obvious one of that system's availability One of those reasons is that American communication companies are equipped,[6] without changes in their circuits or apparatus, to reproduce 5-unit control tapes at a distance, and simultaneously at as many branch factories as may be desired.

From the results obtained by experimental operation of a prototype machine, it may be concluded that automation designers will find a valuable point of departure in the use of electromechanical units already familiar to telegraph engineers; and that the latter might profitably extend their normal interest in the transmission of intelligence signals over wires to comprehend the new uses of signals for the control of mechanisms in the textile industry among others.

REFERENCES

1. Controlling Machine Tools Automatically, **F. W. Cunningham.** *Mechanical Engineering*, New York, N. Y., vol. 76, June 1954. pp, 487–90.

2. System Aspects and Trends of Modern Communication, **I. S. Coggeshall.** *Convention Record*, Institute of Radio Engineers (IRE), New York, N. Y., vol. 2, pt. 8, 1954, pp. 51–62.

3. Embroidery Machine and Coded-Tape Means, **L. Casper.** *U. S. Patent 2,649,065*, August 18, 1953.

4. Teletypesetter Equipment in the Bell System, **M. N. Smalley.** *Bell Laboratories Record*, New York, N. Y., vol. 31, May 1953, pp. 183–6.

5. Diagnostic Programs for the Illiac, **D. J. Wheeler, J. E. Robertson.** *Proceedings*, IRE, vol. 41, October 1953, pp. 1320–5.

6. Teleprinter Codes: 7-Unit Versus 7.42-unit, **F. W. Smith.** *Western Union Technical Review*, New York, N. Y., vol. 8, October 1954, pp. 129–34.

7. Thyratrons in Loaded Cable Multiplex, **H. H. Haglund, A. W. Breyfogel.** *Ibid.* vol. 3, January 1949, pp. 34–42.

8. Automatic Call Recording and Accounting in the SATT System, **J. E. Ostline.** AIEE *Transactions*, vol. 72, pt. I, 1953, pp. 56–62.

INSTITUTE ACTIVITIES

Technical Sessions Overflow at 1955 Winter General Meeting

The AIEE Winter General Meeting was held at the Statler Hotel, New York, N. Y., January 31–February 4, 1955, with a number of the technical sessions overflowing into the Governor Clinton Hotel. The registration was approximately 4,650 members and guests, which was only a little short of last year's record registration.

There were 203 technical papers presented at the 5 days' sessions and 191 conference papers, of which 43 were available in preprint form. This was the first time that members were able to obtain conference papers this way and the innovation was well received.

A program of 14 inspection trips of both technical and general interest were arranged for the members and on the social side, the Sunday afternoon tea, the smoker, and the dinner-dance were enjoyed.

GENERAL SESSION

At the General Session on Monday afternoon, the meeting was called to order by AIEE President A. C. Monteith, whose report on the state of the Institute will be found on pp. 177–8. Awards for the best AIEE papers submitted from August 1, 1953, to July 31, 1954, in the five technical divisions and for the best student papers were presented by W. R. Brownlee, chairman of the AIEE Committee on Prize Awards, to the winners, who were listed on pp. 161–2 of the February 1955 issue of *Electrical Engineering*.

President Monteith then introduced G. Curtis Pritchard, secretary of the Board of Directors of City Trusts, City of Philadelphia, Pa. Mr. Pritchard presented the John Scott Medal, one of the oldest honors in the engineering and scientific fields, to Dr. Marvin Camras, of Armour Research Foundation, "for the invention of the method and means of obtaining distortion-free magnetic recordings through high-frequency bias."

Brigadier General David Sarnoff, chairman of the board, Radio Corporation of America, chose for his feature address, "New Developments in Electronics." (See pp. 179–83.) He described four devices which typify advances made in the electronic arts: tape recording of color video signals; an

Marvin Camras (second from left) receives the John Scott Medal from G. C. Pritchard, Secretary of the Board of Directors, City Trusts, City of Philadelphia, at the General Session, January 31. The award included $1,000. Mr. Camras was given the medal, "For the invention of the method and means of obtaining distortion-free magnetic recordings through high-frequency bias." At left is AIEE President Monteith and at right is AIEE Secretary Hibshman

Future AIEE Meetings

AIEE-IRE-ACM Western Computer Conference
Hotel Statler, Los Angeles, Calif.
March 1–3, 1955
(*Final date for submitting papers—closed*)

Farm Electrification Conference
Morrison Hotel, Chicago, Ill.
March 8–10, 1955
(*Final date for submitting papers—closed*)

Electrical Utilization of Aluminum Conference
William Penn Hotel, Pittsburgh, Pa.
March 15–17, 1955
(*Final date for submitting papers—closed*)

Materials Handling Conference
Hotel Cleveland, Cleveland, Ohio
March 28–29, 1955
(*Final date for submitting papers—closed*)

Rubber and Plastics Conference
Mayflower Hotel, Akron, Ohio
April 4–5, 1955
(*Final date for submitting papers—closed*)

Southern District Meeting
Soreno Hotel, St. Petersburg, Fla.
April 13–15, 1955
(*Final date for submitting papers—closed*)

Middle Eastern District Meeting
Deshler-Hilton Hotel
Columbus, Ohio
May 4–6, 1955
(*Final date for submitting papers—closed*)

Electric Heating Conference
LaSalle Hotel, Chicago, Ill.
May 10–11, 1955
(*Final date for submitting papers—closed*)

AIEE-IAS-IRE-ISA Conference on Telemetering
Morrison Hotel, Chicago, Ill.
May 18–20, 1955
(*Final date for submitting papers—closed*)

AIEE-APS-AIME-CIT Conference on Magnetism and Magnetic Materials
William Penn Hotel, Pittsburgh, Pa.
June 14–16, 1955
(*Final date for submitting papers—March 14*)

1955 Summer General Meeting
New Ocean House, Swampscott, Mass.
June 27–July 1, 1955
(*Final date for submitting papers—March 29*)

Pacific General Meeting
Butte, Montana
August 15–18, 1955
(*Final date for submitting papers—May 16*)

1955 Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 3–7, 1955
(*Final date for submitting papers—June 6*)

electronic refrigerator; a light amplifier; and a music synthesizer. He used sound motion pictures to illustrate these developments and a sound recording to bring to the audience the synthesized music.

On Tuesday, between the morning and afternoon sessions, the John Fritz Medal was awarded to Harry A. Winne, General Electric Company, (see pp. 204–08), and on Wednesday, the Edison Medal was presented to Oliver E. Buckley, retired, Bell Telephone Laboratories (see pp. 209–12).

TECHNICAL PROGRAM

The papers presented at the technical sessions throughout the meeting ran the gamut of the five technical divisions' activities, as well as those of the general committees. Seven sessions were sponsored by the Committees on Safety, Management, Education, and Research.

Safety. Three of the four papers in a session on safety dealt with fibrillation of the heart after an electric shock and research on how the heart can be restored to normalcy without opening the chest cavity. Because of the importance of this subject to the electrical utility industry, the Edison Electric Institute provided funds for a study of defibrillation of the heart to The Johns Hopkins University and it was with some of the findings that these papers dealt.

W. B. Kouwenhoven and W. R. Milnor, both of Johns Hopkins, reported that experiments on animals disclosed that the best method for defibrillation was one application of 60-cycle alternating current flowing through the chest from head to feet. Serial defibrillation, which is current applied over a period of time, was found to be dangerous (see pp. 218–20). In companion papers P. L. Betz, Consolidated Gas and Electric Light and Power Company of Baltimore, Md., described possible sources of power for use in defibrillation (see February *EE*) and S. A. Talbot, of Johns Hopkins, described the effects of electricity on the heart.

"How Can the Utilities Best Make Use of Modern Science?" was the subject of a symposium. Four papers were given presenting the views of a research institute, a utility company, a manufacturer of electrical products, and an educator.

Education. The Committee on Education sponsored two sessions. One of these dealt with the report of the American Society for Engineering Education concerning the evaluation of engineering education and its relationship to electrical engineering as a whole. The other session considered the teaching of physics to engineers: whether the students should be given the point of view of physicists, no matter how modern it may be, or have the subject taught with an engineering slant. It was the consensus that new physics textbooks are needed to provide students with the proper perspective which is required today.

Management. Two papers were given. In the first, L. E. Newman, General Electric Company, explained how The American Society of Mechanical Engineers is helping those in managerial positions by means of symposia and other meetings, and he offered anyone in AIEE interested in the general subjects the co-operation of their experience. J. R. Haas, of Lionel D. Edie and Company, told how today's managers must consider the econonic aspects of their jobs and their company's economic position in the business world.

Electronic Aids to Navigation. The history and problems of long-distance navigation were described and also how radio and electronics have assisted navigators more and more since World War I. An interesting phase of the subject was discussed by Peter Sandretto, Federal Telecommunications Laboratories. This was the electronic aids in landing planes at busy airports in the form of the fixed-beam low-approach radar system and how the control of approaching planes by radar has spread to airports in all parts of the world. Weather still remains a great factor in the landing of planes, but the number of planes which can land in an hour has been increased 20 to 8 in inclement weather, and this is possible only with electronic assistance. In good weather, two planes can land safely every minute.

Switching Systems. One of the most interesting sessions was that devoted to switching systems. Dr. H. F. Olson, RCA Laboratories, presented a technical description of the music synthesizer, which had been announced at the General Session on the opening day of the meeting by General Sarnoff. He explained how all the musical characteristics of different instruments had been analyzed and how they could be reproduced by operating typewriter-like keys which actuate a tape-punching mechanism. He demonstrated the capabilities of the apparatus by playing a tape recording of various musical selections made synthetically without musical instruments.

Two other demonstration papers were given by G. R. Frost and D. W. Hagelbarger of the Bell Telephone Laboratories, which showed the functioning of "Little Audrey," a voice-controlled logic machine which performed various functions when a person told it to do something. The second demonstration, by Mr. Hagelbarger, was a machine which played a guessing game and was smart enough to win a large number of times. Mr. V. F. Blefary then showed how the machines in the two previous demonstrations fitted in with the modern telephone dialing by means of an elaborate demonstration board and a very interesting explanation.

Nucleonics. Five conference papers were given in a session in which latest developments in nuclear machines were described. In his paper, "The Electrostatic Accelerator Today," Alfred Burrill, High Voltage Engineering Corporation, described the van der Graaf accelerator's functioning and stated that there were more than 100 of these machines in use throughout the country at the present time, ranging in size from desk-size machines to those so large they require a special building. The Bevatron and Cyclotron at the Argonne National Laboratory were the subjects of two other papers.

Transformers. Within the last 10 years, more attention has been directed toward the noise inherent in large transformers and means to reduce it to a minimum. Toward this end, the General Electric Company has built a special anechoic chamber where noise tests of large power transformers are being conducted. The design and construction of this chamber as well as measurements of its acoustical properties were the subject of a technical paper by A. W. Benoit, R. T. Hemmse, and M. W. Schulz, Jr.

"Recent Contributions to Transformer Audible Noise Control," by W. B. Conover and R. J. Ringlee, both of the General Electric Company, contained findings and recommendations from their tests on sound barriers and methods for cancelling the transformer sound.

G. Camilli, General Electric Company, in his paper, "An Experimental Gas-Insulated 138-Kv Current Transformer," described a piece of equipment in which the main insulation consists of a fluorinated gas under pressure. It appears that this type of transformer has advantages over the conventional liquid-filled unit, especially for voltages over 115 kv. This unit weighed less than comparable liquid-filled units; it operated in any position; it had unlimited ratio adjustment; and while designed to operate at 10 psig, under certain conditions it operated successfully with the gas at atmospheric pressure.

Semiconductor Energy Converters. George Warfield presided over the Thursday afternoon conference on semiconductor energy converters. The first paper on "Solar Batteries"

Harry Alonzo Winne (center) is shown receiving the 1955 John Fritz Medal from T. G. LeClair, chairman of the John Fritz Medal Board of Award. The gold medal and an engraved certificate were presented during a special session of the Winter General Meeting on February 1. Left to right: C. H. Lang, President Monteith, Mr. Winne, Mr. LeClair, and W. M. Peirce

MEETING HIGHLIGHTS

Jan.–Feb. 1955

Winter Meeting

Top photo (left to right): J. R. Kerner, ladies entertainment; D. M. Quick, vice-chairman, Winter General Meeting Committee; W. G. Vieth, chairman, hotel accommodations; J. P. Neubauer, vice-president District 3; and A. J. Cooper, chairman, Winter Meeting Committee. Bottom left is picture taken at the Board of Directors' Meeting. President Monteith is at the head of the table. Bottom right picture was taken in the registration room at the Hotel Statler

was presented by D. M. Chapin of the Bell Telephone Laboratories, Inc., Murray Hill, N. J. He discussed the efficiency of the solar cell and used 12 in series in demonstrating that the 16-ma output would operate a buzzer. Slides were shown of the variation in available light energy from the sun for different times of the year, and of the variation of cell output for temperatures of −40 to +160 F.

The second paper, "Properties of *p-n* Junctions," was given by W. C. Dunlap, Jr., of General Electric Company, Schenectady, N. Y. He discussed the mechanisms for converting one form of energy to another, such as heat to electric, light to electric, and electric to light. Slides of the P-N junction showed how a shift of energy takes place between the two regions and how the electrical resistance of the material changes at the barrier. The negative temperature coefficient of the crystal semiconductor material was shown.

J. W. Moyer, Knolls Atomic Power Laboratory, presented a paper, "Conversion of Nuclear Energy Using P-N Junctions," and discussed the direct conversion, such as beta rays, alpha rays, gamma rays, and energy released during fission. Pictures were shown of beta-ray converters with germanium efficiencies of 2 per cent and the more favorable silicon efficiencies of 4 per cent, alpha-ray converters using boron and plutonium, gamma-ray converters using stacks of materials, damage effects of gamma radiation, and effects of change in temperature on radiation.

Maria Telkes, of New York University, spoke on "Thermoelectric Generators." She described how generators could convert heat to electric energy without moving parts. Slides were shown of an electric generator in 1880 using a gas burner, efficiencies of thermoelectric generators based on Weltmann-Franz-Lorenz effect, and materials useful in generators. She discussed her search for improved materials, use of reflectors for increased efficiency of sun energy utilization, and the Peltier effect for cooling.

The last paper, "Properties of Silicon Power Rectifiers," was re-presented for discussion by E. F. Losco, Westinghouse Electric Corporation. He described the important features of large and small area units, the d-c and a-c properties, and comparison of forward and reverse current characteristics. Experimental rectifiers capable of handling power output of 500 to 1,200 watts were discussed. He showed slides of the construction of silicon power rectifiers, effect of temperature on forward and reverse characteristics, and heat dissipation when power tested at 100 volts peak inverse as affected by cooling conditions.

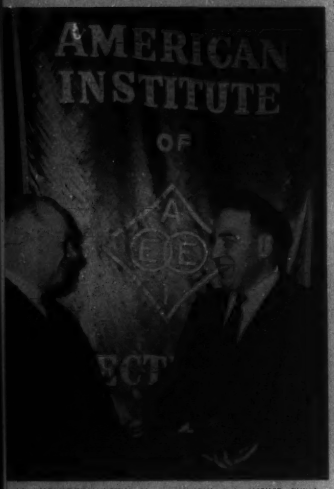
Color Television. R. E. Shelby, National Broadcasting Company, presided over a Tuesday afternoon session in which four conference papers were presented on recent advances in color television.

The first paper, entitled "Design for Production of Color Television Receivers," was given by J. P. Vandune, Television and Radio Division, Westinghouse Electric Corporation. He discussed some facets of the problem in obtaining chromanescence information versus luminescence information, which included converging the output of the three electron guns; obtaining amplitude and hue to agree with the National Television Standards Committee (NTSC) system standards; designing more stable r-f tuner and amplifier circuit; color decoding which requires balancing and phasing adjustments, and making final alignment of the receiver.

Slides were shown of the basic designs in color television receivers, block diagrams of the functions performed, color bar test pattern in which the 920-kc beat is objectionable, a set in the phasing test station during production, and misconvergence to cause blur of the picture. The importance of stability of components, gun balance, mechanical rigidity, and use of adequate test facilities was stressed. Questions were related to the additional handling problems of the heavier sets, and the problem of final adjustment which limited the easy assembly of any home-made equipment.

The second paper by P. C. Goldmark and J. F. Bambara, Columbia Broadcasting System (CBS), New York, N. Y., was presented by Mr. Bambara in the absence of Dr. Goldmark. It described the "Chromacoder," which makes use of the field sequential system, or tricamera system, in which the red, blue, and green are obtained separately, and translates the information to that required by NTSC system. Thus the advantages of the field sequential system are obtained, such as compactness and superior light sensitivity. The equipment, which contains the Emitron tube, is now installed in Studio 72 of CBS in New York. Pictures were shown of the field sequential camera that is similar to the black-and-white camera with a rotating filter, the control room for field sequential system, a block diagram showing scan translation device, Emitro tube and coil system, and diagram for Chromacoder to show how colors are mixed and viewed by the Emitron to give out Y signal. This system has the advantage that the major complication is put in one place, and kinescope recording on film is simplified. Questions dealt with the extent of application bar of the Chromacoder, the phosphor decay rate, and limitations of the system.

A paper on "Development of the Radio Corporation of America (RCA) 21-Inch Metal Envelope Color Kinescope" by H. R. Seelen, Miss H. C. Moodey, D. D. Van Ormer, and A. M. Morrell of RCA, was presented by Mr. Seelen. The tricolor 21AX B22 tube, which is being produced at the rate of several thousand per month, has a 260-square-inch spherical face. The inside of the tube face is given a phosphor coating,



Brig. General David Sarnoff who delivered the principal address at the General Session, congratulates Dr. Marvin Camras. Dr. Camras was awarded the John Scott Medal just prior to General Sarnoff's remarks

0.0009 inch thick, by a new process which permits dot uniformity. The three electron guns produce narrow beams and provide good stability of convergence and optimum coverage of phosphor screen. The frame is spring mounted, and is heated to 400 C during assembly. It gives no misregister, caused either by mechanical or electrical faults, and gives purity of color.

Slides showed the tube and its cross section, diagram for reviewing the advantages of shade-mask operation, cutaway section to show spring-mounting of frame, and an illustration of the ideal condition in which the phosphor dot is beamed on the fluorescent spot. Questions dealt with the use of metal envelope as opposed to glass, use of magnetic materials for shell, and use of shield for the tube.

The last paper, "Deflection and Convergence of the RCA 21-Inch Color Kinescope," was presented by M. J. Obert of RCA. Discussion was given of design of new components to give 70° deflection of electron beam, measurement of deflection by 3-dimensional iron-filing flux plots, formula for convergence efficiency, and bar and dot pattern when beams are converged. Descriptions were given of various yokes, using coils and shields to reduce yoke field coupling. Pictures were shown of beam deflections, coil shapes and sizes, test sets, flux-plot studies of path of electron beam being deflected, complex convergence circuit, and patterns when vertical or horizontal circuitry is used.

These sessions just described were among the highlights of the 81 sessions held during the 5 days of the meeting. It might be of interest to note in passing that certain of the conference papers will be reviewed by the technical committees concerned. If these are found suitable, they will be published in one of the three bimonthly publications of the Institute, which are put together as *Transactions*.

COMMITTEES

The chairmen of the Winter General Meeting Committees were as follows: general, A. J. Cooper and D. M. Quick, vice-chairman; smoker, R. W. Gillette; theater-radio-television, S. Friend, Jr.; ladies' entertainment, Mrs. M. M. Brandon; inspection trips, J. V. O'Connor; dinner-dance, Avery H. Gould; registrations, Morris Brenner; hotel accommodations, W. G. Vieth.

Section Delegates Conference Provides Exchange of Views on Various Activities

Attendance at Section meetings was of principal concern in the discussion which took place on a wide variety of problems with W. R. Hough, chairman of the Sections Committee, presiding. In opening the meeting, the chairman explained that this was not an official meeting, but the conference provided an opportunity for an exchange of information which might indicate ways in which the Institute could be of service to the Sections—and to crystallize topics for the agenda of the official Section Delegate Conference to be held during the forthcoming Summer General Meeting in Swampscott, Mass. The Section activities were reported to be at a high level.

SECTION MEETING ATTENDANCE

By means of slides, a Subcommittee study of Section meeting attendance was presented by Dixon Lewis, vice-chairman of the Sections Committee (East). Conditions were stated as found, without any attempt to draw conclusions in order to obtain the suggestions of the conference. The subject was the result of concern expressed by the Board of Directors about the decline in average attendance per Section meeting shown in a chart entitled "AIEE Sections' Growth and Activity in the Past 15 Years" on the back cover of the annual report. Notwithstanding a 3-fold increase in the number of Section meetings and a 3-fold increase in Institute membership, the average attendance per Section meeting declined from 136 to approximately 70 during the 15-year period. The Board requested the Sections Committee to study the situation and consider appropriate steps for correction or adjustment in activities if the trend indicates a preference on the part of members for a different kind of meeting. In the chart on the cover of the annual report, attendance at technical group meetings and Subsection meetings were not taken into consideration, as these figures were available for the first time last year.

In the discussion, diversion such as television, increased community activities, economic factors, as well as too many organizations and too many meetings, were brought out as contributing factors. Dispersion in smaller groups brought about by the decentralization of industry, as well as the possibility of a decline in the quality of meetings, were not overlooked. The Subcommittee suggested four possible avenues of approach as follows: 1. an opinion poll, which would be costly; 2. broad preliminary survey by a consulting firm; 3. further analysis by the Subcommittee dividing data into groups for large-, small-, and medium-sized Sections, as well as types of meetings; 4. discussion in this conference.

Views were exchanged on various ways of increasing attendance at meetings. The Chicago Section reported good results with a return card system and a personal follow-up by telephone. Another view expressed was that attention should be directed more toward the quality of communications between industries in which an effective job was being done rather than using the attendance per meeting.

Only a few Sections reported difficulty in getting attendance, but the question was raised as to whether the Section programs were giving members what was wanted since a large percentage of the Institute membership never attends any meeting. The Conference did not believe it was necessary for the Subcommittee to carry on the extensive analysis any further.

YOUNG ENGINEERS DIVISION

The representative of the Los Angeles Section, E. A. Wells, reported the successful establishment of a Young Engineers Division with the view toward serving all of the members. The young engineer coming into the Section does not have too much to do, and it takes him a considerable time to find his place among the older group. The plan was developed in so far as possible through the initiative of the younger members. A sponsor for the group has been appointed.

In the Chicago Section, R. B. Gear reported that a group of young engineers had been established for the past 5 years. The group arranges its own programs and obtains speakers on topics of particular interest to them. Over 300 attended a dinner this fall with sponsors who paid part of the cost.

TECHNICAL CONFERENCES

In connection with technical conferences sponsored with Section co-operation, it was reported that when sponsored with the Institute of Radio Engineers (IRE) any surplus that results is divided between the society and the Section. But it is AIEE practice to return any surplus to the Institute treasury. Several representatives believed it would be more equitable if the profits were divided and that better results would be obtained.

The conference voted to recommend to the Board of Directors that consideration be given to dividing the finances so that some local gain might be attained.

SOUND AND SLIDE PROGRAM

A constructive program of sound and slides was outlined by George Bower, chairman of a Subcommittee on Student Branches. One of the objectives of the program is to inform the Sections about what is being done in the Branches so that the Sections can work with

them more effectively. Any Section which has branches in the territory should appoint a committee and actively participate in this activity. The program could also be used at the high school level.

MEMBERSHIP AND TRANSFERS

While the membership had reached a total of 49,243 as of January 1, Chairman W. E. Scholz of the Membership Committee appealed to the representatives of the Sections to check the declining rate of growth. As of July 1, 1954 student enrollment was 6,590 as compared with 6,000 for the same date of the previous year and as of February 1, 1954, the total enrollment had increased to 6,991. Membership committees should look to other sources besides the students for new members. Only about one-third of all electrical engineers are members, and representatives were asked to talk with their Section chairmen to try to get these prospects.

In connection with transfers in grade of membership, the chairman of the Transfers Committee, E. P. Yerkes, drew attention to the pamphlet on "Guide to Transfer in Membership" which is available from Headquarters in limited supply. Two or three representatives reported difficulty in obtaining the required number of references, and Chairman Yerkes advised that they could draw on people outside the AIEE organization of adequate standing to complete the proper number of references. Several Sections expressed desire to obtain the Fellow certificate so that they might have the honor of awarding these certificates.

PRESIDENT'S MESSAGE

The importance of the meeting as a way in which to obtain the views of the members so that the Institute could best serve them was emphasized by President Monteith. He cited as a very important problem the need of getting the services of engineers to the attention of the public.

President Monteith referred to the need to reappraise the organization of the Institute, and the views of members. (The address given by President Monteith appears on pages 177 and 178 of this issue.) An opinion survey would be made by consultants through sampling methods and their recommendations would be obtained. Nothing would be done which would not be done through the Sections, and conferences of this type were considered to be the backbone of the Institute. To a question on unity, President Monteith explained that there were some members on the board of Engineers Joint Council who did not believe that an individual member organization was necessary. Progress taught a unity organization required going through a period of education which would take time. Attention was drawn to the resolution of the St. Louis, Denver, Kansas City, and Pittsfield Sections which proposed that the National Society of Professional Engineers should be the unity organization.

BATON ROUGE SECTION

Chairman Hough explained that on proper recommendation from the Louisiana Section that the Sections Committee had recommended to the Board of Directors that Baton Rouge should be established as the 106th Section. This was subsequently approved by the Board of Directors at its meeting on February 3.

ENGINEER-IN-TRAINING CERTIFICATES

The representative of the Los Angeles Section, E. A. Wells, explained that the engineer-in-training certificate in California posed a problem in membership grades. Graduates from nonaccredited schools who had obtained their engineer-in-training certificates go out into industry and work doing just as good a job or better alongside of Associates; but they have to come in under the Affiliate grade. Belief was expressed that those who take the engineer-in-training examinations and obtain good grades should be admitted to the Associate grade as they are acceptable to the IRE. It was recognized that all states do not have the engineer-in-training examination; but where they exist, it was believed that some mechanism should exist for admission to this grade. The conference voted to go on record as recommending to the Board of Examiners that they thoroughly investigate allowing the admission to the Associate grade of graduates of nonaccredited colleges who have successfully passed the engineer-in-training examinations in cases where the examinations have been adjudged by a competent body to adequately qualify the applicant for Associate Member.

Eta Kappa Nu Recognizes Young and Eminent Engineers

Several hundred members and guests of Eta Kappa Nu attended the annual dinner held at the Henry Hudson Hotel on January 31 to recognize the outstanding young electrical engineers of 1954 and eminent engineers. President Jesse E. Hobson presided at this first official function of the 51st year of Eta Kappa Nu. A cordial welcome was extended to A. C. Monteith, AIEE President, and tribute was paid to the Jury of Awards for its painstaking tasks.

The 1954 Eta Kappa Nu Recognition Award went to Rubin F. Mettler with the citation, "by virtue of his outstanding planning and development of air defense control systems. His participation in civic affairs and his various artistic attainments . . ." Born on a farm near Shafter, California with four brothers and five sisters, Dr. Mettler earned highest academic honors in his class, was a leader in campus politics, varsity athletics, as well as participating in other high school activities. He later attended Stanford University but his education was interrupted by enlistment in the U. S. Navy which advised him to concentrate on engineering. He was selected to attend the Engineering Training School at the California Institute of Technology, where he received his B. S. degree "with honor," later his M. S. in electrical engineering and Ph. D., magna cum laude.

Later while in the employ of the Hughes Aircraft Company in Culver City, he and three colleagues completed the original analysis and systems invention which has subsequently led to the development and production of new and vastly more effective all-weather interceptor fire control systems. At present, Dr. Mettler is a special consultant to the Department of Defense to assist the Assistant Secretary of Defense for Research Development. On acceptance of the bronze bowl replica of the award, Dr. Mettler explained the analytic method of approach to engineering judgment in terms of modern concepts.

Ruben F. Mettler (standing, center) was honored as the outstanding young electrical engineer of 1954 by Eta Kappa Nu Association at the annual Eta Kappa Nu banquet, January 31. Standing with Mr. Mettler are recipients of honorable mention awards: (left to right) Edward E. David, Jr.; Leon K. Kirchmayer; Lindon E. Saline; and Jackson F. Fuller. Eminent Eta Kappa Nu members are seated: (left to right) Dr. E. F. W. Alexanderson, Dr. Alfred N. Goldsmith, and Dr. Harry A. Winne. Dr. Harold S. Osborne, also an eminent member, was absent when picture was taken

Honorable mention went to Edward E. David, Jr. with the citation "by virtue of his exceptional contributions to the art of anti-submarine warfare and his interest in the life of his community . . ." His undergraduate work was taken at Georgia Tech, and he later earned his Master of Science and Doctor of Science degrees at Massachusetts Institute of Technology.

Honorable mention was given to Jackson F. Fuller (AM '45, M '52), manager of engineering, General Electric Company, Denver, Colo., with the citation "by virtue of his notable application of engineering principles and equipment to power systems and his extraordinary activities in behalf of his fellow men. . ." Mr. Fuller received the B. S. degree from Colorado University and in 1953 he received the Charles A. Coffin Award for his development of a simplified portable d-c calculating board which has had wide industrial and power system application.

Honorable mention went to L. K. Kirchmayer (AM '46) with the citation "by virtue of his distinguished research in power systems engineering and his extraordinary participation in civic and professional activities. . .". Mr. Kirchmayer received the B. S. degree from Marquette University and his Ph. D. from the University of Wisconsin.

Honorable mention also was given to Lindon E. Saline (AM '47) with the citation "by virtue of his noteworthy studies and teaching of power systems engineering and his exceptional leadership in cultural and professional organization. . . ." Mr. Saline's undergraduate work was likewise taken at Marquette University and his Ph. D. degree was given by the University of Wisconsin.

EMINENT MEMBERS

The following were elected eminent members of Eta Kappa Nu: Dr. Ernest F. W. Alexanderson, Dr. Alfred M. Goldsmith, Dr. Harold S. Osborne, Dr. Harry A. Winne, and Dr. John B. Whitehead (posthumously).

The eminent members were introduced by Vice-President of Eta Kappa Nu Dr. S. Reid Warren, who referred to their contributions. The response in behalf of the eminent members was made by Dr. Harold S. Osborne who complimented Eta Kappa Nu on the system of honoring the young outstanding engineers. With ample imagination, Dr. Osborne drew attention to some of the things that might be forthcoming and pointed out that one could hardly believe what has been accomplished in one generation in the electrical arts. The young men honored were considered to be in the vanguard of great things which lie ahead, and in conclusion Dr. Osborne extended his full and sincere congratulations to those who had received the awards.

During the ceremonies, dinner guests enjoyed a musical interlude by members of the Bell Laboratories on "The Wobble Organ" invented by Larned Meacham.

AIEE Board of Directors Holds Meeting in New York City

A regular meeting of the AIEE Board of Directors was held in New York on February 3, 1955. A brief outline of some of the actions taken follows. Detailed discussions of major matters will appear in subsequent issues of *Electrical Engineering*.

The following resolution was adopted in memory of Mr. Ernest W. Davis (See p. 260):

Resolved: That, upon behalf of the membership of the American Institute of Electrical Engineers, the Board of Directors hereby expresses deepest regret at the death of Ernest W. Davis (AM '15, M '21, F '34, Member-for-Life), Vice-President (District No. 1) 1946–48, Director 1949–53, and that sincere sympathy be extended to the members of his family.

EXECUTIVE COMMITTEE

Executive Committee actions on membership applications as of November 26, 1954, were reported and confirmed, as follows: 123 applicants transferred, 10 elected, and 1 re-elected to the grade of Member; 1 applicant transferred, 283 elected, and 11 re-elected to the grade of Associate Member; 52 applicants elected to the grade of Affiliate; 1,669 Student members enrolled. As of December 27, 1954: 41 applicants transferred and 5 elected to the grade of Member; 161 applicants elected, and 16 re-elected to the grade of Associate Member; 42 applicants elected to the grade of Affiliate; 697 Student members enrolled.

BOARD OF EXAMINERS

Recommendations adopted by the Board of Examiners at meetings on October 21 and November 18, 1954, and January 20, 1955, were reported and approved, including the following: 43 applicants transferred, and 4 elected to the grade of Member; 1 applicant transferred, 141 elected, and 15 re-elected to the grade of Associate Member; 26 applicants elected to the grade of Affiliate; 223 Student members enrolled.

The Board of Examiners submitted nine proposals for transfer to the grade of Fellow with a favorable recommendation and a recommended citation in each case. The Board of Directors voted to invite the nine Members to be transferred to the grade of Fellow, as follows:

John William Bennett, Western Massachusetts Electric Company, 73 State Street, Springfield 2, Mass.

Kenneth Robb Brown, Brown Engineering Company, Des Moines, Iowa

A. Percival Fugill, chief electrical engineer, The Detroit Edison Company, 2000 Second Avenue, Detroit 26, Mich.

Robert S. Gear, purchasing agent, Commonwealth Edison Company, 72 West Adams Street, Chicago, Ill.

Robert Charles Gorham, profesor of electrical engineering, University of Pittsburgh, Pittsburgh, Pa.

Anthony J. Hornfeck, director of research laboratory, Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio

Ernest L. Michelson, assistant system planning engineer, Commonwealth Edison Company, 72 West Adams Street, Chicago, Ill.

Charles Francis Savage, consultant, professional relations, General Electric Company, 570 Lexington Avenue, New York, N. Y.

Thomas Appleton Taylor, chief engineer, The Pacific Telephone and Telegraph Company, 140 New Montgomery Street, San Francisco, Calif.

More information regarding the aforementioned individuals will appear in *Electrical Engineering* in the department "AIEE Fellows Elected."

FINANCES

Treasurer Walter J. Barrett submitted a written report for the first 9 months of the fiscal year, which ends April 30, 1955, and the Board voted to accept this report.

Chairman Purnell of the Finance Committee reported disbursements from general funds as follows: October 1954—$141,587.61; November 1954—$115,736.66; December 1954—$93,460.65; January 1955—$92,966.71. The report was approved.

Copies of a comparative statement of income and expenses during the expired portion of the present budget year were distributed. It showed that the income to December 31, 1954, was $194,051, or 15.8 per cent of the estimated income for the appropriation year, ending September 30, compared with 17.3 per cent last year. Expenses for the 3 months ended December 31, 1954, were $337,493, or 25.3 per cent of the estimated expenses for the appropriation year, compared with 26.8 per cent last year.

The Board adopted a resolution to drop from membership any member owing dues for the fiscal year ending April 30, 1954, with the understanding that the suspended member may become reinstated without the formality of an application if outstanding dues are paid prior to May 1, 1955.

The Board also adopted a resolution that the Secretary be authorized to accept during the fiscal year beginning May 1, 1955, payment of membership dues on the basis of the par currency value of countries affected by abnormal exchange rates—the member concerned to be granted an exchange allowance corresponding to the difference between the New York exchange value and the normal par of his currency, such allowance not to exceed 40 per cent of the dues payable and not to apply to purchases of, or subscriptions to, Institute publications; a corresponding reduction in appropriation payments to be applicable to Institute Sections in any countries affected.

The Board approved, subject to Bylaw changes, a proposal to make the Budget Year start May 1 to coincide with the Fiscal Year.

The Secretary reported that as of December 31, 1954, the membership of the Institute, not including Students, was 49,243.

RECOMMENDATIONS AND REPORTS

A motion was made and accepted to amend Section 13 of the Bylaws to read:

Section 13. The annual dues shall be as follows:
For Fellows.....Twenty-Five (25) Dollars
For Members.....Twenty (20) Dollars
For Associate Members.....Twenty (20) Dollars

The first six (6) years of membership in Associate Member or Affiliate grade, including any prior membership in either grade, to be at a reduced rate of fifteen (15) dollars.

For Affiliates—twenty (20) dollars. The first six (6) years of membership in the Affiliate grade to be at a reduced rate of fifteen (15) dollars.

Upon recommendation of the Committee on Constitution and Bylaws, the Board approved revisions in the Constitution and Bylaws affecting the requirements for the grades of Member and Associate Member

and the early admission of Student members to the Associate Member grade.

The Committee on Planning and Co-ordination recommended and the Board authorized the holding of a Great Lakes District (No. 5) Meeting in Fort Wayne, Ind., April 16–18, 1956; the 1958 Fall General Meeting in Pittsburgh, and the 1959 and 1960 Fall General Meetings in Chicago.

Chairman R. F. Danner of the Committee on Student Branches gave a report of the activities of his committee.

The Sections Committee recommended and the Board approved the establishment of the Baton Rouge Section, from the Baton Rouge Subsection of the New Orleans Section. The Board also approved the transfer of Calhoun County from the Michigan Section to the West Michigan Section.

It was voted to approve the recommendation of the Publication Committee to print the "AIEE Year Book" every other year. (The next Year Book will be printed in 1956.)

ATTENDANCE

Present at the meeting were: *President* A. C. Monteith; *Past Presidents* D. A. Quarles and Elgin B. Robertson; *Vice-Presidents* C. P. Almon, Jr., A. S. Anderson, G. J. Crowdes, G. D. Floyd, Walter B. Morton, J. P. Neubauer, S. M. Sharp, C. M. Summers, G. C. Tenney, J. R. Walker; *Directors* Donald I. Cone, R. F. Danner, D. D. Ewing, J. H. Foote, L. F. Hickernell, R. E. Kistler, E. S. Lammers, Jr., T. M. Linville, A. C. Muir, C. S. Purnell, E. W. Seeger; *Treasurer* Walter J. Barrett; *Secretary* N. S. Hibshman.

St. Petersburg, Florida, to Be Host for 1955 Southern District Meeting

Plans are nearing completion for the 1955 Southern District Meeting which will be held at the Soreno Hotel in St. Petersburg, Fla., April 13, 14, and 15, 1955. For the fun-loving, arrangements are being made for trips through Florida and for deep-sea fishing.

TECHNICAL PROGRAM

Twenty-four technical sessions are contemplated for the meeting. The technical program places emphasis on progressive Florida and the expanding activities in the southern part of the country. Advance notices indicate that approximately 100 papers will be delivered as part of a well-rounded program covering such diversified subjects as atomic energy and instrumentation, wind tunnels, basic science, phosphate mining, citrus canning, concrete and metal poles, transformers and capacitors, semiconductors, power handling, and plant operation. Final detailed information will be in the April issue of *Electrical Engineering*.

SOCIAL ACTIVITIES AND SPORTS

The Committee has arranged a round of social activities and pleasure trips for the enjoyment of members and their guests. Tuesday evening, April 12, there will be a Hospitality Hour, designed for relaxation and reacquaintance. Coffee, tea, and cocktails will be served. General luncheons will be held on Wednesday and Thursday, and Thursday evening is reserved for a dinner-dance. A cocktail hour honoring AIEE President A. C. Monteith will precede the dinner. Following the dinner there will be entertainment and dancing in the Soreno Dance Hall.

LADIES ENTERTAINMENT

The Ladies Entertainment Committee, under the chairmanship of Mrs. Amy Thompson, has arranged a variety of trips which should provide relaxation and enjoyment. Trips are planned through the orange lands to the Bok Singing Tower and Cypress Gardens with its water skiing show; to Wickiwachee Springs and across the new Sunshine Skyway spanning Tampa Bay to the Ringling Brothers Museum and Winter Circus Headquarters in Sarasota. A coffee hour will be provided each morning.

Men or women interested in sports can play golf on any of three golf courses. Deep-sea fishing in the Gulf of Mexico, then at its best, may also be enjoyed. There will be major league baseball games one block from the hotel.

GENERAL SESSION

Wednesday morning will be devoted to a general session at which addresses will be made by AIEE President A. C. Monteith and Dr. J. Ollie Edmonds, president of Stetson University.

HOTEL ACCOMMODATIONS

Meeting headquarters will be at the Soreno Hotel in downtown St. Petersburg, overlooking Waterfront Park and Tampa Bay. Other nearby hotels will be available also. Requests for reservations should be made directly to the hotels, a list of which will be included in the final program. AIEE should be mentioned in the request and a copy mailed to W. V. Bracken, chairman of the Hotel Committee, Florida Power Corporation, St. Petersburg 1, Fla.

COST OF MEETING ACTIVITIES

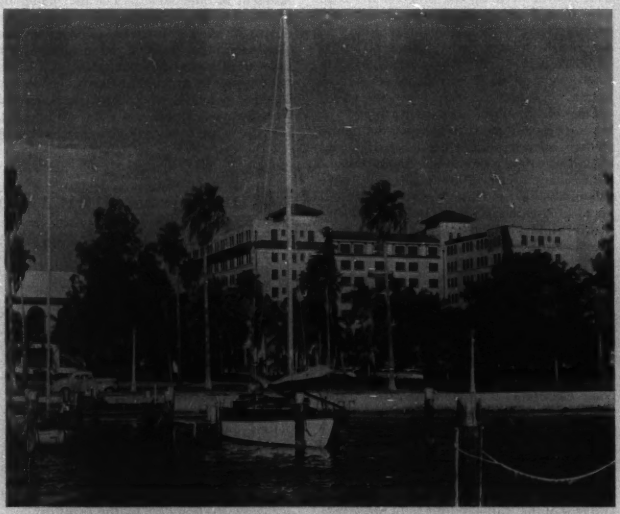
For simplicity of cost accounting, tickets for the different meeting activities are to be issued in a package plan. Cost to members including registration fee, Hospitality Hour, two general luncheons plus Cocktail Hour and Dinner-Dance will be $20.00 (non-members, $25.00). Cost to ladies including two trips with luncheons, Hospitality Hour plus Cocktail Hour and Dinner-Dance will be $20.00.

STUDENTS' ACTIVITIES

The Student Council for District 4 plans to hold a student meeting with 200 students expected from universities and colleges throughout the southern area. This meeting will be held at St. Petersburg simultaneously with the District 4 meeting. Plans include financial help toward the cost of the students' program.

MEETING COMMITTEE

Members of the 1955 Southern District Meeting Committee are: I. L. Garcia, chairman; J. D. Hicks, vice-chairman; Nat Patterson, secretary; Don Knaus, treasurer; W. J. Clapp; M. R. McKinley; J. G. Spencer, Jr.; J. A. Turner, Sr. and C. J. Ellis, advisors; C. P. Almon, Jr., vice-president, District 4; T. H. Mawson, secretary,



Above is picture of the Soreno Hotel, St. Petersburg, Florida, which was taken from Yacht Harbor. All sessions of the Southern District Meeting, April 13–15, will be held at the hotel

District 4; G. L. Kenny, Jr., finance; Ben Darlington, technical program; Turner Loehr, vice-chairman, technical program; Milton Hollis, publicity; Perry Gibbons, student activities; W. V. Bracken, hotel arrangements; T. F. Thompson, Jr., registration; R. E. Raymond, banquet and social; J. H. Rose, trips and transportation; B. R. Gaffner, printing and tickets; and Mrs. Amy Thompson, ladies program.

High-Frequency Measurements Conference Held in District of Columbia, Jan. 17-19

The fourth biennial Conference on High-Frequency Measurements was held in Washington, D.C., January 17–19, 1955, the headquarters hotel being the Statler and sessions of the conference at the Department of Interior auditorium. Beside AIEE, the conference was sponsored by the Institute of Radio Engineers (IRE), the National Bureau of Standards (NBS), and the International Scientific Radio Union (URSI).

In addition to the four technical sessions, at which 24 papers were presented, the Washington Sections of the AIEE and IRE sponsored a demonstration session on Tuesday evening. Inspection trips to four Government laboratories, a cocktail party, and a group luncheon rounded out the program. There were about 350 registrants.

Presiding at the luncheon was R. V. Lowman, chairman of the Joint AIEE-IRE Committee on High-Frequency Measurements, and the speaker was the Hon. Donald A. Quarles, Assistant Secretary of Defense for Research and Development and AIEE Past President.

In his talk, Dr. Quarles brought out that for about 10 years after World War II, the United States held a superior position in the scientific world, but since 1949 Soviet Russia has been drawing up on even terms with us. This is evidenced by the progress the Russians have made in the electronic field; for example, the jamming of the Voice of America broadcasts and the radar antennas on board a Russian cruiser when she was in English waters at Queen Elizabeth's coronation.

One of the most important things the Russians have done is to increase the tempo of their scientific educational activities and we in this country should give more thought to our manpower position in this field. We still tend to have too little basic research compared to research in marketable goods. Action is pending in Congress to set up a federal scholarship program for scientists and engineers which should, in time, better our position.

At the evening session, Dr. G. H. Brown, RCA Research Laboratory, gave a humorous talk entitled "Engineers Are People," which was followed by "An Excursion in Electronics" by C. N. Hoyler, also of RCA. Mr. Hoyler demonstrated the principles underlying electronic computers and the transmission and reception of color television signals.

TECHNICAL SESSIONS

At the opening of the first technical session on Monday afternoon, Dr. A. V. Astin, Director of the National Bureau of Standards (NBS), welcomed the guests and described the move of the Bureau's radio staff to the new $4-million laboratory at Boulder, Colo. He reviewed the work of NBS since the last conference in 1953 and the establishment of AIEE and IRE committees which act as advisors and which have been of great assistance to the Bureau scientists.

The six papers of the first session dealt with the measurement of transmission and reception, which covered rectangular waveguides, transmitting tubes, fixed antennas, and microwave path clearance.

Measurement of power and attenuation was the general subject of the second session. D. A. Alsberg, Bell Telephone Laboratories, presented a description of a 6,000-mc external cavity klystron sweep oscillator, which is capable of delivering 350 milliwatts constant to within ±0.2 db from 5.85 to 6.65 kmc. The sweep width may be varied from 15 to 800 mc and the center of the sweep can be set anywhere in the band. W. H. Spencer and P. D. Strum, Airborne Instruments Laboratory, described the design of broadband uhf and vhf generators, the first one having a uniform spectrum from 200 to 3,000 mc and the vhf generator from 80 to 300 mc. The uhf generator uses a helical transmission line to provide coupling to a gas-discharge tube, while the vhf one utilizes a lumped-constant transmission line.

The third session was devoted to the measurement of impedance. The first paper by H. P. Schwan, University of Pennsylvania, dealt with the measurement of impedance in biophysics. Of practical importance is the knowledge of the dielectric data of various body tissues up to 10,000 mc in order to evaluate the potential health hazards associated with the use of powerful radar equipment. It is also of importance that the mechanism of absorption of electromagnetic energy in tissue be understood in order to promote better apparatus in the field of diathermy.

Other papers in this session dealt with the use of concentric-line transformers in uhf measurements, the figure of merit of probes as standing-wave detectors, the characteristics of microwave comparators, and a method of measuring cavity Q.

The measurement of frequency and time was the general subject of the final session of the conference. A portable frequency standard for navigation was described by P. Antonucci, Rome (N.Y.) Air Development Center, and J. O. Israel, E. B. Mechling, and F. G. Merrill, Bell Telephone Laboratories. The airborne oscillator, a standard stable to 1 part per billion under extreme changes of ambient conditions and this precision, makes possible the measurement of distance with an accuracy of better than 1 per cent during flight periods as long as 8 hours.

A. Bagley and D. Hartke, Hewlett-Packard Company, discussed the problem of accurate determination of carrier frequency during short r-f pulses. By one method a carrier frequency about 1,000 mc modulated by 2.5-microsecond pulses at a 30-cycle repetition rate was measured with an accuracy of ±10 kc.

An instrument for precision range measurements was described by D. H. Beck, Hazeltine Electronics Corporation. The spacing accuracy of the generated reference pulse pairs in this calibrator for time delays is of the order of 10^{-8} second over a range to 10,000 microseconds (μsec). A crystal oscillator provides marker chains and synchronizes the repetition frequency generator. Gating circuits select a fixed and a variable pulse from the 10-μsec chain and a 3-decade electronic counter indicates the selected course delay in multiples of 10 μsec. The device operates with triggered fast-writing oscilloscopes.

COMMITTEE

The Joint AIEE-IRE Committee on High-Frequency Measurements is headed by R. V. Lowman, and D. Keim is secretary. The local committee chairmen were: R. G. Fellers, local arrangements; J. W. Kearney, technical program; F. J. Gaffney, publicity; and J. A. Kaiser was the conference treasurer.

Forum of Technical Committee Chairmen Considers Operating Procedures

In the opening of the Forum of Technical Committee Chairmen, Dr. J. D. Tebo, Chairman of the Committee on Technical Operations, outlined a new procedure for handling conference papers. If an outline or abstract of this type of paper is received 75 days in advance, a conference paper may be placed on the program. If reproducible copies are received 60 days in advance, the paper is made available in pamphlet form, as a preprint. Other conference papers may be brought to the meeting and sold at the registration desk by the Institute.

After the presentation of the conference paper, the discussion is accumulated and retained at headquarters. If the paper is reviewed and accepted, the classification is changed to a Transactions paper and notice of acceptance will be announced in the bimonthly publications and in *Electrical Engineering* with the latest date for receiving discussion.

In the foregoing procedure, re-presentation is not required, but there would be nothing to stop re-presentation if that course seemed desirable. After a conference paper is presented, it should not be changed; otherwise accumulated discussion is irrelevant.

SPECIAL TECHNICAL CONFERENCES

In this area, Dr. Tebo cautioned that arrangements should be made in co-operation

with the Sections in areas where special technical conferences are to be held, as the Sections did not know about the forthcoming conferences.

STUDENT INTEREST

To further student interest, Professor W. G. Dow proposed that one of the bimonthly publications should be made the primary feature of interest, although some of the highly technical matter would not be comprehensive. He drew attention to the inducement offered by the high technical quality of the Institute of Radio Engineers' *Proceedings* and the attractiveness in the word "radio."

PRIZE AWARDS

Committee chairmen were asked to explore the different avenues for recognition awards with their committees. Chairman Tebo would like to receive suggestions with the view toward establishing medals for the recognition of possible achievements.

PUBLICATIONS

In respect to the best way in which the Technical Committee chairmen could help the Publication Committee particularly while operating under a deficit, Chairman Hooven explained that the publication problem was one of mass production. The technical committees could be of greatest help if they would see that the material accepted is up to Institute standards, in reproducible form as prescribed in the "Author's Guide." This would materially assist the staff in processing a large number of papers with a minimum of correspondence but diplomacy should be exercised in cases where material is unsuitable.

BASIC SCIENCE SERIES

With some 57 per cent of the members under 40 years of age, Secretary Hibshman pointed to the need of a series of basic science articles which would be developed by the Basic Sciences Committee for publication in Electrical Engineering to make the magazine more attractive to younger members, and at the same time serve the purpose of good review articles for the older members. The series would be followed up in a subsequent year by more advanced articles on the application of the principles.

INSTITUTE FINANCES

The financial position of the Institute under deficit operation and steps to be taken to rectify the condition were reviewed by W. J. Barrett, Treasurer, (EE Feb. '55, p. 95). The treasurer explained that the difference between income and outgo has become less favorable each year during the last three years and that unless something were done about the situation, the balance would be zero. The deficit at the end of the current fiscal year was estimated to be $100,000 and the downward rate of acceleration over the past three years was at $90,000 per year per year. While the Board of Directors would probably vote to increase the annual dues by $5.00, this would not necessarily assure rectifying the situation. The question was raised whether or not we would be operating in the black or the red with the dues increased. The average income from dues per member was $12.00, which with a membership of 50,000 would produce $600,000 income from dues; however a certain number of members may drop out. If 20% of the members should drop out, the total income dues at an average of $17 per member would be only $680,000 and we would still be in the red. If only 10% of the members drop out, the total income from dues would be $765,000, yielding an increase of $165,000.

The treasurer explained that the Publication Committee had already taken steps to relieve the situation and the advertising rates had been increased 20%. In conclusion, the committees were asked not to take steps that would increase the volume of the publications.

STANDARDIZATION PROCEDURE

The Chairman of the Standards Committee, A. C. Muir, outlined the procedure to improve the liaison between the AIEE technical committees and the work of outside standardizing bodies in the ASA. Professor Dow of the Science and Electronics Division Committee expressed concern over the procedures adhered to by the Standards Committee in a rapidly advancing area where quick results are desired and the refusal to bring out standards involving definitions. Chairman Muir explained that in the Science and Electronics area he was not aware of having received any replies from the technical committees to his letter which had invited the technical committees to name the ASA sectional committees in whose work the technical committees had a particular interest. The Power Division reported that nine out of the 11 technical committees had replied to Chairman Muir's letter and that there was now good liaison representation in this area.

NEXT FORUM

Chairman Tebo called for an expression of views on the frequency of holding these forum meetings. Several technical committee chairmen and officers of the Institute believed that the exchange of views which took place were valuable and the forums might be held as often as there are General meetings. The technical committee chairmen were asked to look out for topics which might be placed on the agenda for the Summer General Meeting at Swampscott, Mass.

Farm Electrification Conference Will Be Held in Chicago

The technical program for AIEE's Farm Electrification Conference has been completed. The conference, which will take place Tuesday, Wednesday, and Thursday, March 8, 9, and 10, at the Morrison Hotel, Chicago, will cover utilization of electricity on modern poultry, dairy, and livestock farms. Power suppliers will discuss methods by which they are serving the present farm load, as well as future plans to serve this rapidly growing load. Problems incidental to power use, such as safety, leakage current, grounding, and underground distributions, will also be covered. The conference will conclude with a look into the future of farm electrification, the future of an electric load which offers the greatest potential increase of any industry in the nation.

REGISTRATION AND HOTEL RESERVATIONS

For advance registration send your name and address, indicating that you plan to attend to: Mr. F. M. Scott, Allis-Chalmers Manufacturing Company, 135 South La Salle Street, Chicago 3, Ill. The registration fee is $3.00, payable at the Conference registration desk.

The Morrison Hotel will hold a number of rooms for the conference. Indicate the accommodation you desire and mail promptly.

For further information about the program, advance registration, or hotel reservations, contact Mr. F. A. Larson, 840 South Canal Street, Chicago, Ill., or Mr. R. S. Gardner, AIEE Headquarters, 33 West 39th Street, New York, N. Y.

INSPECTION TRIP

The Wednesday afternoon session will consist of an inspection trip to modern, electrified, poultry, dairy, and livestock farms. The trip will indicate how the practical farmer in Illinois is using electricity to save time and labor, and to reduce operating costs. Buses leave from the Morrison Hotel at 1:00 p.m.

CONFERENCE COMMITTEE

The Farm Electrification Subcommittee, of the Committee on Domestic and Commercial Applications, and the Chicago Section are sponsors of the conference. Conference Committee members are: Conference Chairman J. H. Oliver, General Electric Company; Chicago Section Chairman H. R. Heckendorn, Western Electric Company; Program Chairman J. H. Oliver; Publicity Chairman F. A. Larson, General Electric Company; Treasurer M. R. Cornelius International Harvester Company; arrangements, R. E. Scheffers, Joslyn Manufacturing and Supply Company; registration, F. M. Scott, Allis-Chalmers Manufacturing Company. The program follows:

Tuesday, March 8

9:00–10:00 a.m. Registration

Morning. Session I.

Chairman: T. H. Cline, Newark Stove Company

10:15 a.m. Welcome to Chicago, *H. R. Heckendorn* Western Electric Company

Why We Are Here Today, *J. H. Oliver,* Genera Electric Company

Research in the Field of Farm Electrification by the Production Economics Research Branch of USDA, *J. F. Davis,* United States Department of Agriculture

The Modern Dairy Farm Is an Electrified Farm, *W. J. Ridout, Jr., Electricity on the Farm*

Afternoon. Session II.

Chairman: H. H. Watson, General Electric Company

2:00 p.m. Mobile Electric Power Comes to the Farm, *C. A. Hubert,* International Harvester Company

The Mobile Electric Power System, *A. F. Lukens,* General Electric Company

CP55-247 Analysis of Single Phase to Three Phase Static Phase Converters, *J. C. Hogan,* University of Missouri

Single Phase Motors for Farm Applications. *S. A. Brown,* Brown Bockmeyer Company; *G. D. Tobias,* General Electric Company; and *B. P. Hess,* Westinghouse Electric Corporation

Wednesday, March 9

Morning. Session III.

Chairman: W. W. Warner, General Electric Company

9:30 a.m. The Modern Poultry Farm Is an Electrified Farm. *J. H. Florea, Poultry Tribune*

How We Serve Heavy Loads for Poultry and Livestock Farms. *Fred Schleter*, Jackson County Rural Electric Membership Corporation

Intermission

10:45 a.m. The Modern Livestock Farm Is an Electrified Farm. *Kirk Fox, Successful Farming*

Modern Rural Distribution Systems to Serve Modern Farm Loads. *G. G. Auer* General Electric Company

Afternoon. Session IV.

Chairman: D. G. Womeldorff, Commonwealth Edison Company

Inspection Trip to modern, electrified, poultry, dairy, and livestock farms. Buses leave Morrison Hotel at 1:00 p.m., and will return to the hotel by 6:00 p.m.

Thursday, March 10

Morning. Session V.

Chairman: H. W. Kelley, Rural Electrification Administration

9:00 a.m. Proper Grounding of Equipment on the Farm. *N. E. Macpherson*, The Hydro-Electric Power Commission of Ontario

Panel: Electrical Standards for the Farm—Are They Adequate for Farm Safety? *C. L. Smith*, International Association of Electrical Inspectors; *H. Whitaker*, Underwriters Laboratory; *Glenn Roswell*, Fire Underwriter Inspection Bureau

Intermission

10:45 a.m. CP55-246 Dynamic Overvoltages on Rural Distribution Systems. *L. B. Crans*, Rural Electrification Administration

Underground Distribution on the Farm. *V. McBride*, Plastic Wire and Cable Corporation

Afternoon. Session V.

Chairman R. E. Smith, Commonwealth Edison Company

2:00 p.m. Keeping Pace with the Rapid Load Growth in the Rural Areas of the Commonwealth Edison System. *D. H. Swanson*, Commonwealth Edison Company

The Future of Farm Electrification. *K. H. Runkle*, General Electric Company

Aluminum Conference Scheduled For March 15, 16, and 17

The first national conference on the electrical utilization of aluminum, jointly sponsored by AIEE's Power Division Committee, and the Pittsburgh Section, will take place at the William Penn Hotel, Pittsburgh, Pa., March 15, 16, and 17. Aluminum utilization from household appliances to industrial and electrical utility apparatus such as transformers, rotating machinery, bus conductors and switchgear, as well as pertinent problems of aluminum manufacture, will be covered at the 3-day meeting.

Hotel rooms are available at the William Penn Hotel. For further information, contact Mr. E. W. Brewer, conference registration chairman, General Electric Company, 535 Smithfield Street, Pittsburgh 22, Pa.

REGISTRATION AND PROCEEDINGS

The Conference Committee urges advance registration for the Conference, banquet, and inspection trips. Advance registration cards may be obtained from Mr. Brewer. Conference proceedings, including all papers and formally written discussions, will be published in book form at $3.50 per copy. The proceedings may be ordered in advance by using the registration card, in which case the combined price for registration and proceedings is $5.50, if ordered before March 8. Registration at the Conference will take place Tuesday at 8:30 a.m. on the 17th floor of the hotel.

Above is view of Pittsburgh, Pa., where AIEE's First National Conference on the Utilization of Aluminum will be held March 15, 16, and 17

BANQUET AND INSPECTION TRIPS

A banquet will take place March 16 at 7:30 p.m. President of the Aluminum Company of America, I. W. Wilson, will speak on "Man's Distinctive Mark."

Inspection trips will be to the following: Westinghouse Electric Corporation, East Pittsburgh Works, Tuesday afternoon and Thursday morning; Aluminum Company of America, Research and Development Laboratories, New Kensington, Pa., Tuesday afternoon; Duquesne Light Company Elrama Power Station, Wednesday afternoon.

CONFERENCE COMMITTEES

Robert N. Wagner is general conference chairman and B. G. A. Skrotzki chairman of AIEE's Power Division Committee. C. T. Hatcher is chairman of the Technical Program Committee. Other members of the Technical Program Committee are: J. A. Adams, H. F. Hoebel, M. H. McGrath, L. R. Montfort, E. I. Pollard, F. V. Smith, J. D. Wood, and R. T. Woodruff, E. S. Reeser, chairman, AIEE Pittsburgh Section, and W. H. Osterle, secretary-treasurer, AIEE Pittsburgh Section. On the Registration Committee are: E. W. Brewer, chairman; and W. J. Martinbee. L. W. Tarn was chairman of the Meeting Rooms and Arrangements Committee, J. E. Lange, chairman of the Banquet Committee, and J. Z. Linsenmeyer, chairman of the Inspection Trips Committee. R. F. Lawrence is chairman of the Publicity Committee, with D. N. Reps to assist him. AIEE Headquarters representative is R. S. Gardner.

Program for the Conference follows:

PREPRINT PRICES

30¢ to Members
60¢ to Nonmembers

MINIMUM ORDER by mail $1.20 unless accompanied by remittance or coupons. All nonmember orders *must* be accompanied by remittance.

COUPON BOOKS in nine-dollar denominations may be purchased.

NUMBERED PAPERS only are available.

SEND ORDER and remittance to:

AIEE Order Department
33 West 39th Street,
New York 18, N.Y.

Tuesday, March 15

Morning. Session I. Switchgear

Welcome Address: R. N. Wagner

Presiding: J. D. Wood

55-257. Development of a Welded Aluminum Bus for Substations. *C. E. Asbury* and *C. J. Hartman*, Commonwealth Associates, Inc.

Aluminum Bus in High Voltage Substations on the Philadelphia Electric System. *J. J. Ray* and *J. F. Calhoun*, Philadelphia Electric Company

Extruded High Strength Aluminum Bus Conductors. *J. C. Warford*, Reynolds Metals Company

Advantages of Aluminum in High Tension Switch Construction. *W. J. Gilson*, Eastern Power Devices Limited

Aluminum in Assembled Switchgear. *R. H. Rutter* and *H. H. Rugg*, Westinghouse Electric Corporation

Afternoon. Session II. Transformers, Regulators and Reactors

Presiding: J. H. Chiles, Jr.

Use of Aluminum in Current Limiting Reactors. *R. L. Brown* and *L. E. Sauer*, Westinghouse Electric Corporation

CP55-258. Application of Aluminum to Dry Type Reactors. *F. H. Headley*, General Electric Company

CP55-252. A Step Type Feeder Voltage Regulator with Aluminum Windings. *C. W. Nielsen*, Allis-Chalmers Manufacturing Company

CP55-251. Use of Aluminum in Oil-Insulated Distribution Transformers. *C. McIntosh, Jr.*, General Electric Company

Evening. Session III. Transformers

Presiding: J. A. Adams

Experience in Design and Manufacture of Dry Type Distribution Transformers with Aluminum Windings. *H. C. Hood*, Westinghouse Electric Corporation

Aluminum Windings for Dry Type Power Transformers. *E. W. Tipton*, Westinghouse Electric Corporation

The Use of Aluminum in Dry Type Transformers. *H. G. Zambell* and *W. M. Terry*, Allis-Chalmers Manufacturing Company

Means of Connecting Aluminum Conductors. *W. A. Barnes*, Utica Drop Forge and Tool Corporation.

Wednesday, March 16

Morning. Session IV-A. Rotating Machinery

Presiding: E. I. Pollard

CP55-254. Use of Aluminum in Fractional Horsepower Motors. *D. J. Harbour*, General Electric Company

55-255. The Transient Stalled Temperature Rise of Cast Aluminum Squirrel Cage Rotors for Induction Motors. *G. M. Rosenberry, Jr.*, General Electric Company

Aluminum Bearings. *D. I. Bohn* and *D. B. Wood*, Aluminum Company of America

The Application of Aluminum to Large Turbine Generators. *C. H. Holley*, General Electric Company

CP55-253. Die Cast Rotors Finishing Treatments. *R. E. King*, Robbins and Myers, Inc.

Morning. Session IV-B. Switchgear

Presiding: C. P. West

CP55-261. Aluminum in Heavy Current Conductors. *W. Deans*, I-T-E Circuit Breaker Company

CP55-260. The Use of Aluminum in the Construction of High Capacity Buses. *K. T. Ashdown* and *N. Swerdlow*, General Electric Company

55-264. Aluminum Widely Used in Power Switchgear. *J. L. Talento*, General Electric Company

Engineering with Aluminum. *J. R. Williard* and *R. R. Cope*, Aluminum Company of America

Effect of Heat Cycles on Bolted Aluminum Bus Joints. *H. E. House* and *N. T. Bond*, Aluminum Company of America

Afternoon. Session V. General Applications and Communications

Presiding: H. F. Hoebel

55-262. The New Look in Lamp Bases. *J. O. Geissbuhler*, General Electric Company

General Utilisation of Aluminum for Electrical Appliances. *E. W. Mason*, Aluminum Company of America

Use of Aluminum Power Cable on Diesel Electric Locomotives. *M. W. Bellis*, General Electric Company and *N. J. Hochanadel*, American Locomotive Company

55-259. Aluminum Die Castings for Carrier Telephone Systems. *L. Pedersen*, Bell Telephone Laboratories, Inc.

A. C. S. R. for Signal and Communication Circuits. H. W. Adams, Reynolds Metals Company

Thursday, March 17

Morning. Session VI. Insulated Conductors and Transmission and Distribution

Presiding: M. W. Ghen

55-249. Design Problems and Operating Experience with Aluminum Distribution Conductors in the Philadelphia Electric Company. *C. E. Nelson* and *K. S. Garrett*, Philadelphia Electric Company

55-256. Eight Years Experience with all Aluminum Distribution System. *H. E. Carpenter*, and *R. E. Thornton*, Oklahoma Gas and Electric Company

An Electrical Distribution System of Aluminum Conductors for a Large Industrial Plant. *R. C. Brosius* and *C. A. Harrington*, McGeorge-Hargett and Associates

Corrosion of Aluminum as Used for Cable Armor in Paper Mill Atmospheres. *B. J. Mulvey* and *J. F. Quinlan*, General Electric Company

Study of Connectors for Use with Large All Aluminum Conductors. *E. C. DeBaene*, *W. C. Franks*, and *E. P. Robertson*, The Detroit Edison Company

Afternoon. Session VII. Insulated Conductors and Transmission and Distribution

Presiding: T. J. Brosnan

Use of Aluminum in Wire and Cable. *C. E. Ambelang*, and *C. E. Betzer*, Commonwealth Edison Company

CP55-263. A Field Study of A.C.S.R. Cable Core in Severe Marine and Industrial Environments. *E. W. Greenfield* and *E. W. Everhart*, Kaiser Aluminum and Chemical Corporation

55-248. Non-Tension Aluminum Connectors. *O. A. Boyer*, Central Power and Light Company and *Emerson Korges*, Texas A & I College

Aluminum Sheathed Control Cable. *E. E. McIlvern*, The Okonite Company.

55-250. The Use of All Aluminum Conductor on Transmission Lines. *E. M. Wright* and *E. G. Lambert*, Pacific Gas and Electric Company

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Engineers Joint Council Holds First General Assembly

Over 350 members of various societies attended the Engineers Joint Council (EJC) First General Assembly held at the Hotel Statler, New York, N. Y., January 21, 1955. The program was comprised of four forums on the following subjects: nuclear engineering developments, employment conditions and unionization, engineering manpower, and service opportunities for EJC. In addition to the forum on engineering manpower, the subject was further explored by the luncheon and dinner speakers. "Competitive Demands for High Grade Manpower" was the subject of Dr. Dael Wolfle, director, Commission on Human Resources and Advanced Training, as well as Administrative Secretary, American Association for the Advancement of Science, who addressed the luncheon. "Engineers and Our National Well Being" was the subject of the dinner address by Donald A. Quarles, Assistant Secretary for Defense, Research and Development, and a Past President of AIEE.

Thorndike Saville, EJC president, presided over the General Assembly, introduced the speakers, stated the objectives of EJC, and explained the procedure. The forums were conducted with panels of experts on the different subjects. Following their statements, the meetings were opened to written questions from the audience. These were answered by members of the panels.

NUCLEAR ENGINEERING DEVELOPMENTS

This forum was opened by Dr. John R. Dunning, chairman, who explained that the subject of nucleonics cuts across virtually every scientific and engineering society's fields of activities, and that in recent years the period of time between discovery and applications has been shortened greatly. Interest has been intensified by the opening up of atomic energy for peaceful purposes. Belief was expressed by Dr. Dunning that EJC is the most effective way through which the goal of co-operative community interests can be realized. To meet the need, EJC will formulate and hold a nuclear congress in Cleveland, Ohio, December 12–17, 1955. This will follow the United Nations Atomic Congress to be held in Geneva in August.

Plans for the organization and program of the Nuclear Congress were outlined by Dr. Donald L. Katz, chairman of the Nuclear Congress Program Committee. Local Arrangements would be handled by the Cleveland Engineering Society, Ralph R. West, president, and arrangements for an exposition are in progress under the direction of Professor Barnett F. Dodge, president of the American Institute of Chemical Engineers. At present 14 groups are co-operating and the policy is to invite any group to participate. Each of the sponsoring societies has been asked to procure papers and review them. Certain papers from the United Nations meeting might be invited for the Cleveland meeting and there will be parallel sessions throughout the week with a program of about 100 papers. There is no intention of creating another organization. The function of EJC would be simply to bring together and co-ordinate this broad field of common interest.

The engineering changes and opportunities introduced by atomic energy were reviewed by Miles C. Leverett of the General Electric Company. The speaker explained that the introduction of atomic energy has broadened the area in which engineers must operate, and the need for men thoroughly trained in

Each one is a president. Left to right are: B. F. Dodge, president of the American Institute of Chemical Engineers; AIEE President A. C. Monteith; and W. R. Glidden, president of the American Society of Civil Engineers. All were present at EJC's First General Assembly

fundamentals was stressed. Opportunities for advancement are unusually great for people with a good technical background. There are many opportunities for engineers in the field of management and their guidance also is needed in economics.

The introduction of atomic energy made for considerable turnover. One could hardly find a nuclear engineer today who has not worked for several companies and growth was not unlike that of the aircraft industry. Both industries were dominated primarily by military considerations and the prospective nuclear engineer would do well to look at the aircraft industry with its great production today to fully realize the opportunities in the field of atomic energy.

EMPLOYMENT AND UNIONIZATION

A statement of the problem and the historical aspects were given by the first speaker, G. Brooks Earnest, Chairman of the panel and vice-president of the American Society of Civil Engineers (ASCE). Factors for the trend toward collective bargaining were summarized under the heading of professional, personnel, financial treatments of employees, and he referred to the complexity of unionization under the Wagner and Taft-Hartley Acts.

Composite data resulting from a questionnaire on employment conditions which had been sent to three constituent societies, ASCE, American Society of Mechanical Engineers, and AIEE, indicated a serious responsibility of first converting a number of members to the true professional status category. The composite data was based on a 57 per cent return from a total mailing of 112,225 questionnaires to members of the three societies. The returns showed that 45,992 or 72 per cent of the 64,206 returns opposed collective bargaining for professional engineers and 42,314 or 66 per cent felt that collective bargaining is incompatible with professional status. However a total of 17,318 or 27 per cent reported as not being opposed to collective bargaining. Furthermore 12,833 or 20 per cent reported that they believed that collective bargaining would be advantageous. Though the thinking of the remaining members (43 per cent of 112,225) who did not respond is not known, it is assumed that their thinking might approximate the 57 per cent who did respond. There would then be 31,500 members who are not opposed to collective bargaining for professional engineers. The responsibility of first converting these 31,500 to true professional status presented a serious challenge to the engineering profession.

The second speaker on the panel, Arthur K. Doolittle, outlined the true meaning of professionalism as applied to engineers, as well as the altruistic motives of the "learned professions" theology, law, and medicine.

The third speaker on the panel, Dean N. W. Dougherty of the College of Engineering, University of Tennessee, answered the question, "Is collective bargaining compatible with professionalism?" emphatically in the negative. He pointed out that in collective bargaining jurisdictions and seniority are in direct conflict with the concept that the ability of the engineer must be recognized and given first place. He further stated that when working conditions are determined by group action, the very nature of professionalism is violated.

The fourth speaker on the panel, E. L. Chandler, assistant secretary of the ASCE, analyzed the responsibilities of engineers in positions of management and the responsibilities of engineers in the ranks of employees. In respect to the composite data from the returns of the employment questionnaire previously mentioned, Mr. Chandler stated, "We are challenged by the circumstance, if so many express a favorable reaction in spite of the fact that the essence of collective bargaining is so foreign to the basic concept of professionalism and to the fundamental thinking inherent in creative engineering."

Among the ways in which management can meet its obligations to professional employees, Mr. Chandler cited the Engineers' Council for Professional Development's program "The First Five Years of Professional Development" to encourage continued education, adequate training, and participation in civic affairs.

ENGINEERING MANPOWER

The forum on engineering manpower convened in the afternoon with T. H. Chilton presiding. The history and current activities of the Engineering Manpower Commission (EMC) were reviewed, as well as the developing military manpower policies and their implications for engineering education and engineering manpower utilization.

In respect to the history, Dean S. C. Hollister said that in 1949 the engineering colleges were overcrowded and coming out of what was known as "The Big GI Bulge." Unfavorable publicity lead to the belief that the field was overcrowded, resulting in a still further shortage. Then the police action in Korea began and the short supply of engineers was acute.

The National Resources Board wrote a letter to Engineers Joint Council and after a survey was made it was clearly indicated that the manpower situation was very grave. After the creation of EMC with the support of the societies, business, and industry, the objectives were as follows: to acquaint the public in general with the situation, to acquaint industry with the problem and to try to bolster the source of supply coming from the high schools.

The second aspect of the panel was devoted to the newly proposed national reserve plan in relation to engineering and scientific manpower. The new national reserve plan was outlined by James M. Mitchell, former Deputy Assistant Secretary of Defense, Manpower Personnel, and Commander Carrison of the Navy. M. H. Trytten, Director, Office of Scientific Personnel, National Research Council (NRC) explained that the effects of this type of program were very hard to predict. Constant review of the program would be required by people who know both the military and industrial needs for scientifically trained personnel.

In response to questions raised in discussion, Mr. Mitchell explained that there was no intention of dropping the Reserve Officers Training Corps (ROTC) units in the proposed reserve plan and that young men with a high intelligence quotient could finish their college work all the way through to the doctor's degree. Few people realize how much education one can obtain in service. One young man who went into service as a junior in high school came out a junior in college.

SERVICE OPPORTUNITIES FOR EJC

This panel was opened by Carlton S. Proctor, past president ASCE, who presided. He referred to recent changes in the EJC constitution with the hope that the organization would truly become the over-all unity agency desired. It is only through unity that the organization can hope to attain true professional status universally recognized. He cautioned against conflicts from within the organization and urged that experiences from the past should be heeded. In conclusion, Mr. Proctor advocated that close liaison with the constituent societies should be maintained through their governing bodies and in this way harmony of interests and cooperative efforts would result.

The organization and work of the Exploratory Group on unity was explained by Dr. H. S. Osborne, chairman of the Exploratory Group and a Past President of AIEE.

The history and accomplishments of EJC as well as that of its predecessor organizations from the time of World War I was discussed by C. E. Davies, secretary, ASME.

LUNCHEON

The feature of the luncheon was an address by Dr. Dael Wolfle, Director, Commission on Human Resources and Advanced Training, and Administrative Secretary, AAAS, on the subject of "Competitive Demands for High Grade Manpower." Dr. Wolfle spoke of the diminishing supply and need for more high school teachers, particularly in the fields of science and mathematics. He also pointed out that there are a number of bright young people who terminate their educations at high school age. If they could be persuaded to continue their educations, the number of scientists and professional people could probably be doubled without any loss in quality. The problem is both social and financial in character. On the social side, it has probably never been developed within these young people that they could lead more useful lives. In solving the problem, the secondary schools, the colleges, newspapers, and the engineering profession could play a very important role.

President Thorndike Saville, who introduced the speaker, also introduced EJC officers and commented to the effect that the engineering profession should have an organization that would represent the entire profession on matters of national import and co-operation among the various societies. He welcomed suggestions in regard to the general assembly and expressed the view that perhaps there were too many subjects on the agenda.

DINNER

The feature of the dinner was an address by Donald A. Quarles, Assistant Secretary for Defense, Research and Development, and a Past President of AIEE, on the subject of "Engineers and Our National Well Being." The scientific and engineering manpower requirements necessary to maintain our national security position in relation to the communist world, were reviewed in the light of advances in weapon technology in the aeronautical, electronic, and nuclear fields. Dr. Quarles said, "If we are to sustain a program that will keep us out ahead in this technological race, our need for engineers and scientists must be expected to increase rather than decrease." The problem should be considered on a national basis and it is important to enhance and conserve engineering manpower which should be disposed

to greatest national advantage. While the military services require some specialists in the performance of their missions, beyond this the nation cannot afford to put engineers and scientists into uniforms. Full text of the address will be published in the April issue of *Electrical Engineering*.

Columbus, Ohio, to Be Scene of Middle Eastern District Meeting

Columbus, Ohio, will welcome the Middle Eastern Meeting, May 4–6, 1955, with headquarters established at the Deshler-Hilton Hotel, opposite Ohio's State Capitol. A full and varied technical program has been arranged for the five session periods. Social events will include a smörgåsbord and a dinner-dance. Five inspection trips are being arranged, including several features not usually seen at District meetings.

TECHNICAL PROGRAM

A total of 22 technical sessions will be on the program. Nine subcommittees have papers on: semiconductors and devices, rotating machinery, management and ethics, atomic power, computers, power systems, communication systems, electronic aids to medicine, and aircraft power systems. Full details of the program will appear in the April issue of *Electrical Engineering*.

OPENING GENERAL SESSION

Featured address at the opening general session will be given by Phillip Sporn, president, American Gas and Electric Company. This will be held Wednesday morning, May 4, at the Deshler-Hilton Hotel.

SOCIAL ACTIVITIES

A smörgåsbord will be held Wednesday evening, May 4th, at the Deshler-Hilton Hotel. A buffet dinner and informal entertainment will be featured. Tickets will be $4.75 per person. The dinner-dance will top Thursday activities. Tickets will be $5.75 per person.

INSPECTION TRIPS

Visits to North American Aviation's Columbus plant, Westinghouse Refrigerator and Freezer Division, and Battelle Memorial Institute, world's largest privately endowed research center, are being arranged. Tentatively scheduled also are trips to the radio telescope at Ohio State University and the American Gas and Electric Company's economic system loading computer.

LADIES' ACTIVITIES

Mrs. P. L. Gilmore, Jr., and her Ladies' Events Committee are also planning a full program. In progress are plans for: tea with Mrs. Frank J. Lausche, wife of Ohio's chief executive, at the Governor's Mansion; luncheon at Ilonka's Provincial House; and an inspection tour through F. and R. Lazarus and Company, one of this country's modern department stores. A daily morning coffee hour also is being planned.

STUDENT ACTIVITIES

The annual student prize paper contest will be held on Friday, May 6th, at the Deshler-Hilton Hotel. A. C. Monteith, President of the Institute, will address the Friday luncheon, with student members admitted free. Prizes will be awarded Friday evening at the Student Banquet to be held at The Ohio Union on the Ohio State University campus.

At right is large seam welder used in Columbus plant of Westinghouse Refrigerator and Freezer Division. Tops and bottoms of refrigerator food compartments are seamwelded to the outside shell by this machine. Six seam welds are made simultaneously

HOTEL ACCOMMODATIONS

Blocks of rooms have been set aside at the Deshler-Hilton Hotel for members and guests. Requests for reservations should be sent directly to the hotel. AIEE should be mentioned in the request. Reservations should be made prior to April 18, 1955. No reservations should be sent to the Hotel Subcommittee.

COMMITTEE APPOINTMENTS

Members of the 1955 Middle Eastern District Meeting General Committee are: E. K. McCoy, general chairman; G. M. L. Sommerman, honorary general chairman; R. C. McMaster, advisory; L. M. Moore, administration; G. R. Tamplin, co-ordinating secretary; N. J. Greene, budget and finance; D. E. Stafford, treasurer; E. E. Dreese, technical program; N. A. Smith, student meeting; C. K. Bishop, special meetings; P. L. Gilmore, Jr., entertainment; J. W. Cade, arrangements; E. O. Wolden, publicity.

Program Announced for Annual Rubber and Plastics Conference

The Seventh Annual AIEE Conference on Rubber and Plastics will be held at the Mayflower Hotel, Akron, Ohio, Monday and Tuesday, April 4 and 5. Sponsor of the Conference is the Subcommittee on Rubber and Plastics of the Committee on General Industry Applications. Subcommittee chairman is W. S. Watkins. Secretary-treasurer for the conference is Robert Condon, and R. D. Heyburn is chairman of the Local Arrangements Committee.

Everett S. Lee, past president of the Institute and editor of the *General Electric Review*, will deliver the keynote address: "What Does Automation Mean to a Processing Industry?" A banquet will take place Monday at 6:30 p.m. in the Mayflower Hotel ballroom. The banquet speaker will be announced, as will the inspection trip scheduled for Tuesday afternoon.

Monday, April 4

Morning

Keynote Address: **What Does Automation Mean to a Processing Industry?** *E. S. Lee*, General Electric Company

The Status of Automatic Process Control in the Rubber and Plastics Industries. *Hale and Kullgren*, consulting engineers

Electric Drives for Rayon and Nylon Tire Fabric Machines. *C. E. Robinson*, Reliance Electric and Manufacturing Company

Comparison of Continuous Thickness Measuring Systems. *R. F. Snyder*, Goodyear Tire and Rubber Company

Automatic Weighing Systems. (*Author to be announced*)

Evening

Banquet, Mayflower Hotel Ballroom.

Tuesday, April 5

Comparison of Electronic, Rotating Regulators and Magnetic Amplifiers. *J. P. Montgomery*, Westinghouse Electric Corporation

Report of Special Committee on Contaminated Atmospheres. *E. L. Smith*, Firestone Tire and Rubber Company

Effect of Requirements of the Rubber and Plastics Industries on Motor Design. *C. E. Miller*, General Electric Company

Closing Paper (*Subject to be announced.*) *Paul Dickey*, Bailey Meter Company

Afternoon

Inspection Trip

Crane Conference to Be Held in Cleveland, Ohio, March 28–29

The Materials Handling Subcommittee of the AIEE General Industry Application Committee is planning a technical conference on electrical overhead cranes to be held at the Cleveland Hotel, Cleveland, Ohio, March 28 and 29. Included in the program will be sessions on overhead traveling cranes, grab buckets and crane collector systems, and an inspection trip to the Ford Motor Company's engine plant. A total of 11 papers will be presented by recognized authorites on the design, application, and operation of overhead cranes.

Monday, March 28

Morning. Session I. Overhead Traveling Cranes

Chairman: E. J. Sohn, Bedford Foundry and Machine Company, Inc.

Industry Application Requirements. *Edgar C. Rice*, The Noble Company

When AC—And Why, *W. C. Carl*, Westinghouse Electric Corporation

When DC—And Why, *E. J. Parrott*, Cutler-Hammer, Inc.

When Adjustable Voltage—And Why, S. Rifkin, General Electric Company

Afternoon. Session II. Grab Bucket Cranes

Chairman: F. M. Blum, Harnischfeger Corporation

Grab Bucket Cranes—The Production Tool of Bulk Handling. *K. Nuestlein*, Harnischfeger Corporation

Principles of Clamshell Bucket Operation and Service Life Performances. *Arnold Hooper*, Blaw Knox Company

Control of Grab Bucket Cranes in Industry. *A. H. Myles*, The Electric Controller and Manufacturing Company

Tuesday, March 29

Morning. Session III. Crane Collector Systems

Chairman: R. E. Stephan, Dravo Corporation

Safety Aspects of Sliding Conductor Systems with Comments on Rail and Shoe Materials. *H. T. Magesch*, Electric Service Manfacturing Company

Automatic Take-Up Reels For Supplying Power to Equipment in Motion. *C. E. Stryker*, Gleason Reel Corporation

Power Supply, Taps, Size and Spacing of Conductors *C. Brongersma*, Manning Maxwell and Moore, Inc.

Maintenance, Cleaning and De-Icing of Collector Systems. *D. C. McCrady*, Steel Company of Canada

Afternoon. Session IV. Inspection trip to Ford Motor Company, engine plant

Discussion and Question Period for All Papers

AIEE Luncheon at American Power Conference

The 17th annual meeting of the American Power Conference will be held on March 30–31, and April 1 at the Sherman Hotel in Chicago, Ill. A program of interest to those engaged in almost every activity relating to generation, transmission, distribution or utilization of power will be presented. The conference is sponsored by the Illinois Institute of Technology in co-operation with 14 universities and 10 national and regional societies throughout the United States.

AIEE will sponsor a luncheon Thursday, March 31, at 12:15 p.m. in the Bal Tabarin Room of the hotel. AIEE President A. C. Monteith will preside and H. R. Heckendorn, chairman of the Chicago Section, will also be present as assistant chairman.

For registration information write to: R. A. Budenholzer, director, American Power Conference, Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Wednesday, March 30

9:00 a.m. Registration

10:00 a.m. Opening Meeting

Invocation

Where We Stand Today in the Electric Industry. *J. W. Everts*, president, Commonwealth Edison Company

Research in the Utility Industry. *H. P. Seelye*, Detroit Edison Company

12:15 p.m. Luncheon

Sponsored by the American Society of Mechanical Engineers

Speaker: Harold Quinton, president, Edison Electric Institute, and president, Southern California Edison Company

2:00 p.m. Central Station Steam Generators

Chairman: H. H. Hemenway, Jr., Foster Wheeler Corporation

2:00 p.m. Water Resources

Chairman: R. H. Bradford, Ebasco Services, Inc.

2:00 p.m. Industrial Steam and Power

2:00 p.m. Electronic Applications

Closed-Circuit Television Systems and Their Applications In Industry. *P. A. Lovelock*, General Precision Laboratory

Multi-fuel Boiler Control. *Paul Thanos*, Inland Steel Company

Fault Location with Radar Equipment. *H. L. Garton*, Commonwealth Edison Company

3:30 p.m. Research in Steam Generators

7:30 p.m. General Interest Panel Session: Development of Atomic Energy for Power Purposes

Panel Members: Philip Sporn, president, American Gas and Electric Company, Representing the Nuclear Power Group; Walker L. Cisler, president, Detroit Edison Company, Representing the Atomic Power Development Associates (others to be announced).

Thursday, March 31

9:00 a.m. Research in Steam Turbines

Advances in Large Steam Turbine Research and Development. *H. D. Emmert*, Allis-Chalmers Manufacturing Company

The Laboratory as an Engineering Tool in Steam Turbine Research and Development. *F. K. Fischer*, Westinghouse Electric Company

Research and Development in the Field of Turbine-Generator Prime Movers in the General Electric Company. *G. B. Warren*, General Electric Company

9:00 a.m. Water Technology I

Symposium on Operation of Demineralizers for Treating Makeup for Steam Power Plants

9:00 a.m. Industrial Applications

The Impact of Air Conditioning on the Electric Utility Industry. *Fischer Black, Electrical World* (magazine)

Principles of Automatic Controls. *John Diebold*, John Diebold and Associates, Inc., *Automatic Controls Magazine*

The Importance of Complete Cooperation of Heavy Equipment Manufacturers with Utilities. *O. V. Talley*, Allis-Chalmers Manufacturing Company

9:00 a.m. Electric System Planning I

Overall Planning of Systems for the Long Range Future. *H. L. Melvin*, Ebasco Services, Inc.

Location of Future Generation—Economic Analysis. *G. P. Wilson*, Illinois Power Company

Industrial Power Distribution—Bus Duct or Load Centers. *Harry Decker*, General Motors Corporation

10:30 a.m. Electric System Planning II

Area Studies and the Prediction of Load Growth. *E. L. Kanouse*, Department of Water and Power (Los Angeles)

Possibilities for Greater Regional Coordination of Power Systems in the United States. *Francis L. Adams*, Bureau of Power, Federal Power Commission

12:15 p.m. Luncheon

Sponsored by the American Institute of Electrical Engineers

Chairman: A. C. Monteith, president, American Institute of Electrical Engineers

Associate Chairman: H. R. Heckendorn, chairman, Chicago Section, AIEE

Speaker: C. H. Linder, vice-president, General Electric Company

2:00 p.m. Central Station Power Plants

Panel discussion (participants to be announced)

2:00 p.m. Fuels No. 1

2:00 p.m. Developments in Small Gas Turbines

2:00 p.m. Electrical Distribution I

Distribution Trends and Obsolescence. *L. M. Olmsted, Electrical World* (magazine)

Voltage Divider Method of Capacitor Switching, *H. C. Stone*, Line Material Company

3:30 p.m. Automatic Generating Equipment for Utilities

Mobile Electric Automatic Generating Equipment for Utilities. *B. F. Hefner, K. O. Bower*, and *E. A. Armstrong*, General Motors Corporation

Starting Requirements for Isolated Central Station Engine Driven Generators. *A. Hofman*, Westinghouse Electric Corporation; *Leo Brinson*, Nordberg Manufacturing Company.

3:30 p.m. Electrical Equipment

Use of Magnetic Amplifiers in Excitation Control. *T. J. Bliss*, Westinghouse Electric Corporation

The Philosophy of Modern Generator Voltage Regulators. *H. W. Gayek, A. S. Rubinstein*, and *M. Temashok*, General Electric Company

New Excitation System Without Comutators. *W. L. Ringland* and *H. W. Cory*, Allis-Chalmers Manufacturing Company

6:45 p.m. All Engineers' Dinner

Presiding: Fischer Black, *Electrical World* (magazine)

Friday, April 1

9:00 a.m. Gas Turbines for Power Plants

Chairman: *John I. Yellott*, Bituminous Coal Research, Inc.

Associate Chairman: *Ben Skrotzki, Power* (magazine)

Combined Gas Turbine Steam Turbine Power Plant Cycles. *A. A. Hafer*, and *W. B. Wilson*, General Electric Company

A 15,000 kw Gas Turbine Power Plant. *T. J. Putz*, Westinghouse Electric Corporation

Application of Gas Turbines to Nuclear Power Plants. *Howard Grantz*, General Electric Company

9:00 a.m. Cooling Towers for Central Station Plants

Chairman: *A. R. LeBailly*, Sargent and Lundy, Engineers

Associate Chairman: *J. T. Anderson*, Michigan State College

Cooling Towers—Their Influence on Prospective Plant Sites. *R. W. Gaumann*, Indianapolis Power and Light Company

Cooling Towers for the Power Industry. *F. J. Lockhart, J. M. Whitsell*, and *A. C. Catland, Jr.*, The Fluor Corporation, Ltd.

9:00 a.m. Water Technology II

9:00 a.m. Electrical Distribution II

Distribution System to Meet Rapidly Growing Residential Loads. *H. H. Watson*, General Electric Company

Distribution Systems to Meet Increased Domestic Loads. *H. E. Lokay*, Westinghouse Electric Corporation

10:30 a.m. Water Technology III

10:30 a.m. Electrical Industrial Session

Series Capacitors Eliminate Voltage Fluctuations in Industrial Plants. *T. H. McGrew*, Sargent and Lundy, Engineers

Dry Type Versus Liquid Cooled Transformers for Industrial Systems. *W. M. Terry*, Allis-Chalmers Manufacturing Company

10:30 a.m. Industrial Steam Generators

12:15 p.m. Luncheon

Sponsored by the Western Society of Engineers.

Solar Energy. *Farrington Daniels*, University of Wisconsin

2:00 p.m. Progress in Nuclear Technology for Power Generation

Reactor Research and Development. *W. K. Davis*, Atomic Energy Commission

Sodium Reactor Power Plant. *Chauncy Starr*, North American Aviation

Technology and Basic Economics of Nuclear Fuels. *Walter Zinn*, Argonne National Laboratory

Power From Atomic Energy. *C. H. Gay*, The Babcock and Wilcox Company

2:00 p.m. Water Technology IV

Sponsored by Joint Research Committee on Boiler Feedwater Studies

2:00 p.m. Computers and Network Analyzers

Application and Design of Penalty Factor Computer. *C. A. Imbrogio*, and *G. W. Stagg*, American Gas and Electric Service Corporation; *K. R. Geiser*, and *L. K. Kirchmeyer*, General Electric Company

Operating Experience with the World's First Incremental Cost Computer for Delivered Power. *E. D. Early*, Southern Services, Inc.

Analyzer Features Made Possible by Zero-Loss Reactors. *W. Atherton*, I-T-E Circuit Breaker Company

Operation and Design Consideration of a 60-Cycle Network Analyzer. *S. N. Witts*, Northern States Power Company, and *R. E. Koll*, System Analyzer Corporation

Summary of Network Analyzers in Operation in the United States and Canada. *E. T. B. Gross*, Illinois Institute of Technology

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Official Nominees Announced for 1955 AIEE National Election

M. D. Hooven, electrical engineer, Public Service Electric and Gas Company, Newark, N. J., was nominated for the AIEE presidency by the AIEE Nominating Committee at its meeting held in New York, N. Y., January 31, 1955. Others nominated for election to Institute offices for terms beginning August 1, 1955, are:

For Vice-Presidents:

C. T. Pearce, Middle Atlantic Engineering and Service Manager, Westinghouse Electric Corporation, Philadelphia, Pa. (*District 2*)

W. J. Miller, professor and head of Department of Electrical Engineering, University of Alabama, University, Ala. (*District 4*)

E. R. Jones, toll circuit layout supervisor, general plant department, Mountain States Telephone and Telegraph Company, Denver, Colorado. (*District 6*)

Bradley Cozzens, executive assistant to general manager, Water and Power Department, City of Los Angeles, Calif. (*District 8*)

B. G. Ballard, Director, Radio and Electrical Engineering Division, National Research Council of Canada, Ottawa, Ontario, Canada. (*District 10*)

For Directors:

J. D. Tebo, science editor, Bell Telephone Laboratories, New York, N. Y.

P. G. Wallace, head, Design Division, engineering department, Texas Power and Light Company, Dallas, Tex.

J. C. Woods, station design engineer, Commonwealth Edison Company, Chicago, Ill.

For Treasurer: Walter J. Barrett, electrical co-ordination engineer, New Jersey Bell Telephone Company, Newark, N. J.

The Nominating Committee, in accordance with the Constitution and Bylaws, consists of 20 members, one selected by the executive committee of each of the ten geographical Districts, one selected by each of the five technical divisions, and five selected by the Board of Directors from its own membership.

The Constitution and Bylaws of the Institute require publication in *Electrical Engineering* of the nominations made by the Nominating Committee. Provision is made for independent nominations as indicated in the following excerpts from the Constitution and Bylaws:

Constitution: Section 32. Independent nominations may be made by a petition of twenty-five (25) or more corporate members sent to the Secretary when and as provided in the Bylaws; such petitions for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

Bylaws: Section 24. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 32 (Constitution), must be received by the secretary of the Nominating Committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the Nominating Committee in accordance with Article VI of the Constitution and sent by the secretary to all qualified voters on or before April 15 of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

A list of members of the Nominating Committee appeared in the January issue of *Electrical Engineering*, p. 75.

To enable those Institute members not acquainted personally with the nominees to learn something about their engineering careers and their qualifications for the Institute offices to which they have been nominated, brief biographical sketches are scheduled for inclusion in the "AIEE Personalities" columns of the April issue.

Virginia Polytechnic Branch Enters Float in Parade

The AIEE-Institute of Radio Engineers (IRE) Student Branch at Virginia Polytechnic Institute took active part in the school's "Home-coming Day" parade last October 30 at Blackburg, Va. The occasion was the annual alumni reunion.

The Branch's float consisted of "Reddy Kilowatt" who was on a football field. Reddy, the field, and the rest of the float were covered with aluminum foil furnished by Reynolds Metals Company located in Richmond. AIEE was on the left, side, and IRE the right.

Summer General Meeting to Combine Business and Pleasure

The 1955 AIEE Summer General Meeting will be held in Swampscott, Mass., June 27 to July 1, with headquarters at the New Ocean House. Swampscott provides an ideal location to combine business with pleasure—an AIEE meeting with a New England vacation. It is approximately 15 miles north of Boston, near Marblehead, famous yachting center on the Atlantic coast, as well as near the White Mountains of New Hampshire and the Maine coastline.

The Lynn and Boston Sections will be hosts for the meeting, and General Chairman Mark A. Princi has reported that all committees have their plans near completion. There will be a diversified technical program and a wealth of social activities and inspection trips.

Hotel accommodations have been reserved in the nearby towns of Marblehead, Lynn, and Salem, and also in Boston, and Swampscott. Transportation will be available from all these points to convention headquarters.

Members of the General Committee and committee chairmen for the 1955 Summer General Meeting to be held at Swampscott, Mass. June 27–July 1. Front row (left to right): J. F. Archibald, Secretary J. R. Macintyre, Vice-Chairman C. W. Maloney, Chairman M. A. Princi, J. A. Cook, S. M. Osthagen, District 1 Vice-President G. J. Crowdes. Standing (left to right): E. A. Harty, N. Stadtfeld, Jr., R. E. Franck, A. M. Bjontegard, J. R. Cornell, Jr., P. H. Houser, Treasurer R. G. Slauer, and E. K. Rohr. Absent when picture was taken: E. W. Davis, L. F. Cleveland, T. C. Sargent, G. E. Wall, and Mrs. M. A. Princi

Also, for those who will be driving and would prefer the motel type of accommodations, there are several excellent modern motels nearby. The Hotels Committee will be glad to advise as to arrangements.

Members desiring further information should contact Mark A. Princi, General Chairman, AIEE Summer General Meeting, General Electric Company, West Lynn Works, 40 Federal Street, Lynn, Mass.

Dayton Section Tours Wright-Patterson Base

Members of the Dayton Section toured the wind tunnels of the Wright-Patterson Air Force Base last November 10. Approximately 175 members participated. After arrival at the wind tunnel area, the Section was divided into small groups so that individual lecturers at various observation points could discuss topics of interest.

One tunnel observed was the Center's Massie Memorial Tunnel which has a 40,000-hp variable-speed induction-drive motor. This is the largest motor of its type ever built. The tunnel probably has more data recording equipment and probably produces more scientific data than any other wind tunnel in the world. Large-capacity cooling equipment is required by the tunnels because of the heat generated by the compression and friction of high-speed air flows.

The world's largest single-stage centrifugal compressor is installed there also. It provides 2,100 tons of refrigeration at 70 F. If all of the tunnels are operating at the same time, they consume more than 67,000 kw of electric energy.

AIEE Heating Conference to Feature New Developments, Techniques

The second biennial electrical heating conference sponsored by AIEE's Committee on Electric Heating will be held at the La Salle Hotel in Chicago, Ill., May 10 and 11. Sixteen papers covering latest developments and techniques in industrial heating will be presented during the four half-day sessions. Among timely subjects to be presented are:

1. Vacuum melting in large quantities.
2. Dual-frequency induction heating for forging.
3. Furnace brazing.
4. New method of aluminum and magnesium brazing.
5. Fundamentals of metallurgy in the heating of metals.
6. Radiant heating.
7. Unusual applications of the salt bath furnace.
8. New applications of dielectric heating.
9. 60-cycle heating of ferrous materials.

Papers on these and other subjects will be presented by such recognized authorities as: J. D. Nesbit, director of research, Universal Cyclops Steel Company; C. A. Tudbury, manager of engineering, The Ohio Crankshaft Company; H. M. Webber, application engineer, General Electric Company; N. K. Koebel director of research, Lindberg Engineering Company; L. B. Rosseau, vice-president, Ajax Electric Company; and B. E. Baker, chief engineer, Magnethermic Corporation.

Left: Lt. Col. Blakes Lambert gives a general briefing of the wind tunnels to members of the Dayton Section during a tour at the Wright-Patterson Air Force Base. In background is a removed portion of the test section of the Massie Memorial Tunnel. Picture at right shows a group in the Control Room

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Power Division

Committee on Relays (*Frank von Roeschlaub, Chairman; W. K. Sonnemann, Vice-Chairman; G. W. McKenna, Secretary*). The Committee met in Toronto, Ontario, on September 28, 1954, and the reports of the various Subcommittees, and Project Committees indicated that progress was being made on the following: a revision of standards for power relays, a brochure on transmission-line relaying, a questionnaire on the need for and the application of loss-of-field and negative-sequence current relays for generator protection, a chapter on protective relaying for inclusion in an AIEE publication on industrial plant electrification, suggested changes in the standards for bushing current transformers, an investigation into test methods, and a survey on load shedding and system separation. A new Project Committee to review the general field of motor protection met for the first time at this meeting.

Future plans include a session with the System Engineering Committee and possibly another survey of general relaying practices.

Science and Electronics Division

Committee on Instruments and Measurements (*J. G. Reid, Jr., Chairman; Ernst Weber, Vice-Chairman (East); W. S. Pritchett, Vice-Chairman (West); C. F. Savage, Jr., Secretary*). The Committee has, for all practical purposes, completed its reorganization as required to encompass the broad scope inherent in the technology of measurement. Under a form where Group Subcommittees have jurisdiction over certain fields of measurement as delineated by devices, individual meetings have been held and the methods of procedures made clear to the members. For example, the Group Subcommittee on Telemetering requires seven Subcommittees and liaison with 13 other committees or societies. This in turn requires an expanded membership, but with every member active on a project, this assures continuing interest on an expanding scale that is required and is consistent with a growth pattern of telemetering itself. The other Group Subcommittees are also organized to be adequate for the Committee's long-range planning.

Recognition that certain areas of measurement, notably the aviation and the electronic, are being emphasized in the West Coast area has led to special effort being directed to increasing the activity of the AIEE participation there. This is in line with the principle of where there is interest there should be adequate activity. Since the concentration in geophysical instrumentation is in the Southwest, the Committee also recognizes its responsibility for increased representation in this geographical subdivision.

To get complete understanding of the Committee's and the Institute's operations across to each member of the Committee is part of a planned program. The procedure in connection with the processing of technical papers is an item of special interest in this area. A task force committee is operating to draw a "circuit diagram" indicating how papers are processed under the procedures as outlined in the "Author's Guide" and "Technical Sessions' Guide." These are pamphlets which Headquarters uses to govern publication of papers. The object is to assure that publication of worthwhile information is not neglected and that all authors obtain proper recognition of their output consistent with the quality of the communication.

Work is continuing in the Subcommittee on Definitions ASA *C-42*, on the Power Test Code, on the revision of ASA *C-41* and the *C-39.2*. Liaison work with Technical Subcommittee No. 1 of ASA Subcommittee *C-63* is active. The gigantic task of gathering together and preparing for publication of the telemetering bibliography has been completed. This, together with a glossary of telemetering terms which appeared in the February *Electrical Engineering* to promote discussion, will significantly permit co-ordination in this field of measurement. The 1954 National Telemetering Conference was successful and the 1955 Conference is being planned.

The Committee also participated in the First International Instrument Congress and Exposition in co-operation with other societies. This was felt to be worthwhile.

Cognizance is being taken of the new technology in electrical engineering and the need for measurement, with many varieties and kinds of appliances. Automation, transistor testing and a great deal of measurements to cover radiation are examples of this interest. Other new technologies, such as data reduction and environmental testing are under continued surveillance.

AIEE PERSONALITIES.....

F. H. Rockett, Jr. (AM '47), patent engineer, Airborne Instruments Laboratory, Inc., has been appointed director of sales and advertising with The Airpax Products Company, Baltimore, Md. He will co-ordinate the marketing and promotion of choppers, vibrators, magnetic modulators, and specialty relays and transformers. Mr. Rockett is a graduate of Lehigh University, 1943, from which he has a bachelor of science degree in electrical engineering. He has taught at Lehigh University and at Columbia University. He was also with the editorial staff of *Electronics* magazine at one time. In 1949 Airborne Instruments Laboratory invited him to its publications section as editor and shortly promoted him to technical report consultant in the office of the vice-president for research and development. In this capacity he assisted with and co-ordinated the preparation of engineering reports and instruction manuals. He was appointed patent engineer at Airborne in November 1953. Mr. Rockett is a member of the Institute of Radio Engineers, Radio Club of America, and Instrument Society of America. He is the author of 18 interpretive and survey articles and of numerous reviews of technical books.

W. T. Johns, Jr. (AM '44), vice-president, Rumsey Electric Company, Philadelphia, Pa., has been elected a director of the company. Mr. Johns makes his headquarters in Richmond, Va. He was born in Richmond in 1901 and is an electrical engineering graduate from Virginia Polytechnic Institute, class of '25. After graduation he joined the Virginia Electric and Power Company, Richmond, in the distribution engineering department, overhead and underground. In 1929 he joined Rumsey as sales representative. He later became regional manager and then vice-president. He served as chairman of AIEE's Virginia Section (1948–49).

M. A. Lipton (M '46), wire systems engineer for the Signal Corps Engineering Laboratories, Fort Monmouth, N. J., has been appointed to the advanced systems engineering group of that organization. He will participate in long-range systems planning activities, serving as staff specialist on communications for automatic weapons systems. Mr. Lipton has been associated with the Signal Corps Engineering Laboratories for over 14 years and has served there in various capacities, as wire and cable development engineer, systems engineer, and communications consultant.

E. W. Engstrom (F '49), vice-president in charge of research, RCA Laboratories Division, Radio Corporation of America, has been elected to the board of directors of the Radio Corporation of America. Mr. Engstrom is a graduate of the University of Minnesota. He was born in Minnesota in Minneapolis, and has the University of Minnesota's Outstanding Achievement Award among many other honors. He joined RCA in 1930 as an engineer and was elected vice-president in charge of research of the RCA Laboratories Division in 1945.

A. B. Bronwell (AM '34, M '44), professor at Northwestern University, Evanston, Ill., has been elected president of Worcester (Mass.) Polytechnic Institute (WPI). He has been on the Northwestern electrical engineering faculty since 1937 and jointly, for the last 7 years, he has held the position of executive secretary of the American Society for Engineering Education. He is a native of Drexel, Ill. WPI's president-elect was graduated from Illinois Institute of Technology in 1933 and took his master's degree there in 1936. His association with Northwestern began the following year. He be-

came professor of electrical engineering in 1947. That year also, he received his master's degree in business administration at Northwestern. He did graduate study in physics and engineering at the University of Michigan in 1939 and 1940. He assisted in the design of the new Technological Institute building at Northwestern, and from 1941 to 1947 organized the electrical engineering department's daytime and evening graduate programs. In addition to his academic work, he has been in industry. He was a special project engineer for Bell Telephone Laboratories, New York, N. Y., in the summer of 1941, and was an engineering consultant from 1941 to 1945 for Galvin Manufacturing Company. He organized and supervised, in 1941 and 1943, the American Signal Corps School in radio and preradar for officer candidates at Northwestern. During the next 2 years, he supervised a wartime research project on air-borne radar. In 1953, he received a grant from the National Science Foundation for research on a new principle of detection and conversion of microwaves. This project was carried on by graduate students. He holds a patent on a viewing tube for color television pictures. He was editor of the *Journal of Engineering Education* from 1947 to 1952, and has written numerous technical articles. He is coauthor of "Theory and Application of Microwaves," a textbook. His "Advanced Mathematics in Physics and Engineering" was published last year.

W. S. Ginn (AM '37, M '49), general manager, power transformer department, Transformer Division, General Electric Company, has been appointed general manager of the Transformer Division at Pittsfield, Mass. **F. E. Fairman, Jr.** (M '41, F '51), vice-president and general manager of the Transformer Division, has resigned. Mr. Fairman has been in ill health for the past year. However, he will continue to serve the company as a consultant to the Division's general manager. Mr. Ginn, a native of Atlanta, Ga., has been general manager of the power transformer department for the past 2 years. He joined General Electric in 1936 after graduation from Georgia Tech. He was first assigned to the engineering training program in Pittsfield and Schenectady. Early in 1941, Mr. Ginn entered the U. S. Navy. He was assigned to the *U.S.S. Saratoga*, where he was engineering officer. Near the end of World War II, and for a few months following, he was assigned to the Bureau of Ships in Washington. He was released to inactive duty late in 1945 with the rank of lieutenant commander. Mr. Ginn returned to the Pittsfield Works, and in August 1947, was appointed assistant manager of the Power Transformer Sales Division. He was appointed manager of this division in October 1947, and became assistant manager of sales for the Transformer and Allied Product Divisions in September 1949, and manager of sales in June 1950. In January 1952, he was appointed general manager of the power transformer department. Mr. Fairman was elected a vice-president of the company in January 1953, and was named general manager of the Transformer and Allied Products Division, which is now the Transformer Division, in 1951. He is a native of Pittsburgh, Pa., and was graduated from the U. S. Naval Academy in 1921. After spending some time in the fleet, he resigned from the Navy and joined General Electric Company in 1923 as a requisition engineer in the Baltimore works. He was a junior electrical engineer with the Pennsylvania Water and Power Company during 1925, and then returned to his former position at General Electric. In 1928 he was named switchgear specialist for the apparatus department's Pittsburgh office, and 2 years later was designated steel mill specialist for that district. He was later put in charge of steel mill sales for the Pittsburgh office, and in 1933 was transferred to the Switchgear Divisions at Philadelphia. Mr. Fairman became sales manager of the Panel and Equipment Division in 1939 and was appointed assistant manager of the Switchgear Divisions in 1941. From 1945 to 1949 Mr. Fairman was vice-president of the Food Machinery and Chemical Corporation and general manager of its Peerless Pump Division, with headquarters in Los Angeles. In 1949 he returned to General Electric, becoming manager of sales for the Transformer and Allied Product Divisions. He was named general sales manager of the Large Apparatus Division in 1950, which was followed by his appointment to general manager of the present Transformer Division in 1951.

Robert Bry (AM '53), transformer specialist, General Electric Company, has become manager, feeder voltage regulator sales, in General Electric Company's power transformer department at Pittsfield, Mass. As manager of feeder voltage regulator sales, he is now responsible for the sales and promotion of feeder voltage and inductrol regulators. A native of Deal, N. J., Mr. Bry served 4 years in the U. S. Army Signal Corps prior to his graduation from Cornell University in 1948 with a B. S. M. E. degree. He went to Pittsfield immediately after graduation as an engineer in feeder voltage regulators. In 1950 he joined the sales section and became a traveling specialist for both power transformers and regulators in 1952, a position he held until his recent appointment.

J. N. Ratcliff, Jr. (AM '49), has been appointed district manager for the Houston (Tex.) Sales District, of Anaconda Wire and Cable Company.

C. F. Carnish (AM '50), service engineer in Detroit, Mich., since 1951 for The Reliance Electric and Engineering Company, Cleveland, Ohio, has been promoted to a district sales engineer, reporting to the Detroit district manager. Carnish, a native of Cleveland, attended Case Institute of Technology, and upon joining Reliance in 1947, worked for more than 3 years in the company's electronic laboratory.

R. T. Morris (AM '50), Distribution Transformer Sales Division, General Electric Company, Pittsfield, Mass., has been appointed manager of lightning arrester and cutout sales for General Electric Company's distribution transformer department at Pittsfield, Mass. Mr. Morris replaces **H. M. Towne,** who retired recently. (See December *Electrical Engineering*, p. 1134.) Born in 1919 at Easton, Pa., Mr. Morris received a B. S. degree in mechanical engineering in 1941 from Lafayette College at Easton. He joined General Electric shortly after graduation. He then served on active duty with the U. S. Naval Reserve from 1942 to 1946. Following his discharge, he was a junior proposition engineer at Pittsfield for 2 years. Then he transferred to Chicago, Ill., as a transformer specialist, remaining there until 1951 when he returned to Pittsfield. He was appointed supervisor, distribution transformer sales, and since January 1954, has been manager of marketing, administration, and personnel development.

A. C. Hall (M '44, F '50), associated technical director, Research Laboratories, Bendix Aviation Corporation, has been appointed general manager of the research laboratories. Dr. Hall studied electrical engineering at the Agricultural and Mechanical College of Texas from which he received the bachelor of science degree. Graduate work was carried on at the Massachusetts Institute of Technology (MIT) from which he received the doctor of science degree. Dr. Hall joined the staff of the electrical engineering department of MIT in 1937 and served progressively in the capacities of assistant, instructor, assistant professor, and associate professor until 1950. In 1940, he helped organize the Servomechanisms Laboratory at MIT, set up to develop control mechanisms to meet the military needs of World War II. He was instrumental in developing the science of automatic controls and his work is the basis of the sign techniques now widely used in this field. He was responsible for the development of the first automatic tracking systems for radar for aircraft as well as the first tracking system for shipboard radar. Toward the latter part of World War II, Dr. Hall directed a group in the development of the control system for the first successful naval guided missile, the BAT. In 1946, Dr. Hall was made director of the dynamic analysis and control laboratory at MIT. In 1950, he left MIT to become associate director of the research laboratories of the Bendix Aviation Corporation. In 1952, he became technical director of that laboratory. In 1946 he received the Naval Ordnance Development Award for his work in guided missiles and in 1947 received honorable mention for Eta Kappa Nu Association's "Outstanding Young Electrical Engineer Award." He is a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi, a senior member of the Institute of Radio Engineers, a member of The American Society of Mechanical Engineers, and of the Association for Computing Machinery.

C. G. Appleman (AM '49), sales engineer, Roller-Smith Division, Realty and Industrial Corporation, Bethlehem, Pa., has been appointed to the position of application engineer in Line Material Company's Milwaukee, Wis., headquarters. He will be concerned with problems in the fields of power switching and substation structures. He has several years of industrial and utility experience in the development engineering of substation standardization and the application of switching equipment. An electrical engineering graduate of Pennsylvania State College, he is a member of the Institute of Radio Engineers and the American Radio Relay League, as well.

K. A. Norton (AM '41, M '48), National Bureau of Standards (NBS), has been appointed chief of the Radio Propagation Engineering Division of the Boulder, Colo., laboratories of the National Bureau of Standards. Mr. Norton has been a member of the NBS staff since 1946, and also served previously at the Bureau in 1929 and 1930. He was a consultant in the radio propagation section of the Office of the Chief Signal Officer from 1944 to 1946, radio and tactical countermeasures analyst in the operational research section of the Eighth Air Force in England from 1943 to 1944, and assistant director of the operational research group in the Office of the Chief Signal Officer from 1942 to 1943. Prior to World War II, he was on the staff of the Technical Information Section of the Federal Communications Commission for a number of years. He has also spent a year at Columbia University and worked for the Western Electric Company, as well.

OBITUARIES • • • •

Ernest W. Davis (AM '15, M '21, F '34, Member for Life), director of engineering for the Simplex Wire and Cable Company, died on January 11, 1955, from a heart attack. Born March 3, 1890, in Auburn, Maine, he graduated from Massachusetts Institute of Technology with the class of 1913. He joined the engineering department of the Simplex Company two weeks before he graduated. From then until 1932 he was assistant electrical engineer. Subsequent to that he was promoted to chief electrical engineer, and chief engineer. In 1950 he was named director of engineering. He served AIEE in many capacities and in addition to his contributions to AIEE, Mr. Davis was president of the Insulated Power Cable Engineers Association at the time of his death. He was a member of the International Society of Municipal Electricians, the International Electrical Inspectors Association, the American Standards Association, the American Mining Congress, and the National Society of Professional Engineers. He was an Associate Member of the Institution of Electrical Engineers (Great Britain). In addition to activities in his professional work, he was quite active in community and social affairs. He served AIEE as vice-president, District 1, (1946–48); as director (1946–48, 1949–53); and on the following committees: Applications to Marine Work (1939–40), Power Transmission and Distribution (1939–43), Electric Welding (1946–48), Land Transportation (1946–48), Insulated Conductors (1947–55), Mining and Metal Industry (1947–55), and was representative on the Engineers' Council for Professional Development (1947–50). He was also a member of the Institute's Board of Examiners (1949–55).

Ernest W. Davis

A. G. Birdsall (AM '14), Ebasco Services, Inc., New York, N. Y., died December 31, 1954. Mr. Birdsall had been an Associate Member of AIEE for 40 years. He joined the Institute 2 years after graduaton from Lehigh University where he took the electrical engineering course. He was born at Toms River, N. J., in 1891 and received his elementary and preparatory education in Toms River grade and high schools. He joined the General Electric Company, in Pittsfield, Mass., in 1912 in the testing department. The following year he transferred to the same department of the company in Schenectady. In 1914 he joined the commercial department of the Lehigh Navigation Electric Company, South Bethlehem, Pa.

Welton V. Johnson (AM '47), president of Welton V. Johnson Engineering Company, Summit, N. J., died last Thanksgiving Day. Mr. Johnson was born in Brahm, Minn., and attended schools there. He received his B. S. degree in electrical engineering from the University of Minnesota in 1926. He joined Westinghouse Electric Corporation, in East Pittsburgh, Pa., in the meter engineering department. Mr. Johnson later moved with this department to its plant in Newark. In 1946 he left Westinghouse to form his own company. He was a licensed professional engineer in New Jersey.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of January 20, 1955, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Abetti, P. A., insulation development engr., General Electric Co., Pittsfield, Mass.
Alexander, E. C., engineer, Illinois Bell Telephone Co., Chicago, Ill.
Allen, T. J., transmission supt., Georgia Power Co., Atlanta, Ga.
Backentoss, H. B., project manager, Jackson & Moreland, Boston, Mass.
Bell, W. M., application engineer, General Electric Co., Schenectady, N. Y.
Broverman, M., manager, pole-type distr. transf. engg., General Electric Co., Pittsfield, Mass.
Brunton, E. W., electrical engineer, Black & Veatch, C. E., Kansas City, Mo.
Candee, A. H., motive power consultant, The National Supply Co., Pittsburgh, Pa.
Chausse, B. P., circuit development engineer, General Electric Co., Schenectady, N. Y.
Cox, A. S., electrical engineer, Illinois Power Co., Decatur, Ill.
Davis, L. L., division superintendent, Southwestern Public Service Co., Borger, Tex.
Decker, E. N., Jr., electrical engineer, General Electric Co., Pittsfield, Mass.
Demy, R. H., chief electrical & mechanical engineer, The Hudson Coal Co., Scranton, Pa.
dePool, N. S., electrical engineer, The Detroit Edison Co., Detroit, Mich.
Emerson, T. B., staff engineer, The Pacific Tel. & Tel. Co., San Francisco, Calif.
Fargo, R. J., electrical engineer, Bouillon & Griffith, Seattle, Wash.
Fehr, F. S., electrical engineer, Metropolitan Edison Co., Reading, Pa.
Gilmour, A. R., design engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Graze, D. W., principal electrical engineer, PSD, City of Burbank, Calif.
Hinton, O. T., Jr., plant engineer, Poinsett Lumber & Mfg. Co., Pickens, S. C.
Hoffman, N. W., head, standards & specification engineer, Wisconsin Electric Power Co., Milwaukee, Wis.
Jacobs, W. E., asst. supt., Consumers Power Co., Grand Rapidr, Mich.
Jeffers, W. W., project engineer, Duquesne Light Co., Pittsburgh, Pa.
Johnson, R. G., asst. electrical engineer, Pioneer Service & Engineering Co., Chicago, Ill.
Judkins, R. P., design engineer, aviation engg. dept., Westinghouse Electric Corp., Lima, Ohio.
Kenworthy, O. E., consulting electrical engineer, 632 Charles Ave., Kingston, Pa.
Kirk, R. C., chief engineer, Kyle products, Line Material Co. Div., McGraw Electric Co., South Milwaukee, Wis.
Krieble, R. H., manager, chemical development dept. General Electric Co., Pittsfield, Mass.
Landauer, W. E., project engineer, Airborne Instruments Laboratories, Inc., Mineola, N. Y.
Lawrence, W. L., design engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Lee, T. H., engineering analyst, General Electric Co., Schenectady, N. Y.
Lines, C. W., system operator, Georgia Power Co., Atlanta, Ga.
Marshall, J. A., supervisor, General Electric Co., Philadelphia, Pa.
Martin, T. D., local mgr., Orland district, Pacific Gas & Electric Co., Orland, Calif.
Moore, L. F., asst. distribution engineer, Knoxville Utilities Board, Knoxville, Tenn.
North, C. R., engineer, Philadelphia Electric Co., Philadelphia, Pa.
O'Neil, S. J., electrical & engineer, Parke Mathematical Laboratories, Inc., Concord, Mass.
Parks, W. K., application engineer, Westinghouse Electric Corp., Buffalo, N. Y.
Poe, H. V., associate professor of electrical engineering, Clemson Agricultural College, Clemson, S. C.
Rahe, C. H., electrical engineer, Pennsylvania Water & Power Co., Baltimore, Md.
Rosenstein, A. B., lecturer, University of California, West Los Angeles, Calif.
Sayre, J. A., manager of districts, Iowa Power & Light Co., Des Moines, Ia.
Shorter, C. H., manager of engineering, General Electric Co., Richmond, Va.
Smale, J. H., engineer, Indianapolis Power & Light Co., Indianapolis, Ind.
Sokol, W. J., senior engineer, Bechtel Corporation, San Francisco, Calif.
Sullivan, J. B., supervising engineer, Iowa Power & Light Co., Des Moines, Ia.
Summers, O. V. (retired), 2020 Wroxton Road, Houston, Tex.
Trout, E. D., consulting radiation physicist, General Electric Co., Milwaukee, Wis.
Wartinbee, W. J., application engineer, General Electric Co., Pittsburgh, Pa.
Watters, C. V., system planning engineer, Salt River Power District, Phoenix, Ariz.
Webster, E. W., physicist, Massachusetts General Hospital, Boston, Mass.
Woods, K. H., senior distribution engineer, Southwestern Public Service Co., Amarillo, Tex.
Woodson, J. T., electrical engineer, W. R. Holway & Associates, Tulsa, Okla.

53 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before March 25, 1955, or May 25, 1955, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Betts, A. L., Washington State College, Pullman, Wash.
Coleman, R. M., (Re-election), Graphite Metallizing Corp., Yonkers, N. Y.
Copping, H., E.C.C. Canada Ltd., Toronto, Ont., Canada
Farnham, G. W., The Ronald Press Co., New York, N. Y.
Joicey, T., Pyrotenax of Canada Ltd., Trenton, Ont., Canada
Langford, R. C., Weston Electrical Instrument Corp., Newark, N. J.
Milnes, A. G., Carnegie Institute of Technology, Pittsburgh, Pa.
Oldenburger, R., Woodward Governor Co., Rockford, Ill.
Storey, T. E., City of Winnipeg Hydro Elec. System, Winnipeg, Manitoba, Canada

9 to grade of Member

OF CURRENT INTEREST

Color Television Used in First Intercity Consultation and Diagnosis by Pathologists

Color television of government-approved standards was used for the first time recently as a means of intercity consultation and diagnosis by pathologists in combating disease. This presentation was conducted jointly by the Armed Forces Institute of Pathology (AFIP) and the Radio Corporation of America (RCA).

While a noted father-and-son team of surgeons, Dr. I. S. Ravdin and Dr. Robert Ravdin, stood by in an operating room of the University of Pennsylvania Hospital in Philadelphia, Pa., tissue they had removed from a patient was examined by a waiting pathologist, Dr. Robert Horn, and color television sped microscopic views of the specimen to pathologists in Baltimore, Md., and Washington, D.C., for consultation with them in the diagnosis.

After examining the image of the section on a television receiver in Baltimore, Dr. Hugh G. Grady, Director of the American Registry of Pathology, AFIP, commented on the results of his diagnosis. His remarks were carried instantly to Washington and to Philadelphia.

This demonstration was followed by two additional 15-minute programs employing RCA compatible color television equipment on an intercity basis to explore the value of this medium as a revolutionary new tool for medical and pathological diagnosis, consultation, teaching, and research.

The 45-minute presentation highlighted a 3-day symposium sponsored by the AFIP to bring together for the first time men of medicine and industry to investigate and discuss how color television can best be used in the fight against disease. The AFIP is the central laboratory for the United States Army, Navy, and Air Force, as well as other government agencies, and also provides diagnosis and consultation services for civilian pathologists.

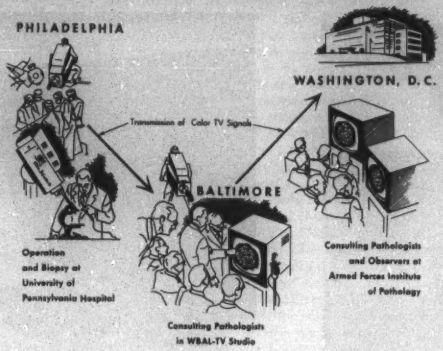
More than 150 pathologists and observers attending the symposium participated in the presentation while assembled before standard RCA color television sets in a hall of the new atomic-attack-resistant building of the Institute in northwest Washington. A smaller group of consulting pathologists took part from a studio of WBAL-TV in Baltimore, where they also were able to witness scenes and action transmitted by closed-circuit color television from Philadelphia. A color camera at WBAL-TV later covered the diagnostic consultation there. Subsequent portions of the color television presentation were designed to illustrate the effectiveness of this medium in the dissemination of pathological information and techniques over distances, and in conducting important pathological conferences between individuals and groups in widely separated locations throughout the country.

In the opinion of Dr. Alfred N. Goldsmith, pioneer electronics engineer and inventor, who participated in the earlier meetings of the symposium in Washington, color television is now ready to serve the medical profession in many ways. "This intercity presentation, which so effectively brought pathologists together for the first time through the use of color television, should prove to be an eye-opener for the entire medical profession," declared Dr. Goldsmith.

As illustrations of color television and facsimile utilization in medicine, Dr. Goldsmith mentioned the following: viewing automatic-multitrace oscilloscope or recording devices or tapes which, for example, show the frequency, amplitude, and relative phase of the rhythm components present in electroencephalography; similar observations of a group of traces, either transient or recorded, in electrocardiography; pathologic diagnosis by grouped and advisory consultants or specialists wherever located, and having convenient access to recorded data in the specific field of diagnosis; measurements at one or more central locations of blood-cell counts, cell-diameters, and related diagnostic factors; study of successively televised and photographed (or otherwise recorded) specimens, or fields of study, for the determination of progressive differences or changes; "sonic pictures," made with ultrasonic wave penetration whether in monochrome or color—if in color, a technique resembling that for making X-rays in color may be used; observation and analysis of mass-spectrophotometric curves or records, for chemical or micro analyses (for example, using electron-beam probes and a corresponding spectrometer, with probe guidance through the use of an optical microscope); and centralized inspection of wards and operating rooms, as well as individual patients in a hospital or clinic.

"It is clear, then, that color television and its various adjunct services, efficiently used, will become an increasingly valuable asset of the medical profession," declared Dr. Goldsmith. "In effect, color television can and

(Left) a projection microscope, used to project views of tissue specimens for pickup by RCA color TV camera during part of the presentation which originated from the University of Pennsylvania Hospital in Philadelphia, Pa., is shown. Projection is made from periscope-like device jutting from the top of the microscope. At doctor's right is a "quick-freeze unit" which freezes specimens so that they can be thin-sliced for use in microscope. (Right) nerve center of first use of color television for intercity diagnosis and consultation is this control room in a mobile color TV unit parked outside the University of Pennsylvania Hospital


PHILADELPHIA
WASHINGTON, D. C.
Transmission of Color TV Signals
BALTIMORE
Operation and Biopsy at University of Pennsylvania Hospital
Consulting Pathologists and Observers at Armed Forces Institute of Pathology
Consulting Pathologists in WBAL-TV Studio

Color television of Government - approved standards was used for the first time as a means of intercity consultation and diagnosis by pathologists in combating disease. The schematic drawing (right) shows the origination point and the progress of a joint presentation by the AFIP and RCA

will give the medical profession's universities, lecture rooms, consultation rooms, wards, clinics, and laboratories a scope as wide as the country and will provide to all of these an interconnection means as speedy as light itself."

EJC Publishes Results of Engineers' Income Survey

A survey to determine the professional income of engineers was conducted and the results published by the Engineers Joint Council (EJC).

Usable income and salary information was received from 295 companies employing more than $2^1/_2$-million people and 65,169 engineers. Twelve Government agencies (federal, state, and local) submitted information on 3,892 engineers. No data on self-employed engineers are included.

In the field of engineering education, questionnaires were distributed by department heads to members of their staffs who returned them directly to EJC. Of these returns: 2,904 had information on teachers' salaries only; 2,977 had data with respect to total professional income.

The samples obtained represent about 18 per cent of engineers employed in industry, 30 per cent of those engaged in engineering education, and 4 per cent of those employed in Government, not including the armed services.

Copies of "Professional Income for Engineers, 1953" may be obtained from the Engineers Joint Council, 33 W. 39th St., New York, N. Y. Prices to member of EJC constituent societies is $1.00; prices to nonmembers is $2.00.

IRE National Convention to Have Outstanding Features

An attendance of 40,000 is expected for the 1955 national convention of the Institute of Radio Engineers (IRE) to be held on March 21–24, in New York City. The program will include 55 technical sessions and 704 engineering exhibits, covering almost every new development in the communication and electronic field. Technical sessions are scheduled for 4 days at the Waldorf-Astoria Hotel, Kingsbridge Armory, and Belmont Plaza Hotel. The Radio Engineering Show exhibits will fill the 4-acre floor of the Kingsbridge Armory and overflow into the Kingsbridge Palace, located $1^1/_2$ blocks away.

Among the other features of the convention will be: the annual meeting of the IRE on the opening Monday morning, which will feature a talk by A. V. Loughren, director of research of the Hazeltine Corporation; a get-together cocktail party Monday evening; and the annual IRE banquet Wednesday evening at which Gen. Matthew B. Ridgway, chief of staff of the U. S. Army, will be the principal speaker.

The technical program will be highlighted by two special symposia on Tuesday evening on "Magnetic Recording for the Engineer" and "Trends in Automatization of Procedures and Processes in Business and Industry." The remainder of the program will cover a wide variety of interesting and important subjects, such as spurious radiation, remote control of space stations, and designing machines to simulate the behavior of the human brain.

National Inventors Council Prepares List of Technical Problems

A list of problems, "Technical Problems Affecting National Defense," has been prepared by the National Inventors Council in co-operation with the armed services. It is designed to acquaint industry, science, and the creative lay public with some of the problems which are currently confronting the scientific and technical personnel in the military groups. Despite the fact that the Government's military establishment is constantly carrying on extensive research and development programs, there is always a need for new ideas, and it is hoped that distribution of the list will stimulate the submission of possible solutions to these problems or the suggestion of new approaches or new techniques which may lead to solutions.

Problems are in the fields of aeronautics, electronics, electromechanics, power generation and distribution, measuring equipment, components, and materials. Problems were furnished the council by the armed services with the understanding that the council would assume responsibility for correspondence, interviews, and related work up to the time when a specific constructive proposal was in hand. It is at this point that the descriptive material on the proposed solution is referred to the armed services for study, and it is at this time that direct contact with the services is arranged for those who have presented promising solutions.

No special forms are required for submitting proposals to the council. The description should be as nearly complete as the inventor can make it and might well include some reference to the principles underlying the apparatus, a discussion of any experimental work or tests that have been conducted, and the particular points of novelty or superiority of the invention as compared to existing devices or practices. The written material may be supplemented by any sketches or drawings the inventor wishes to include.

The council itself, designed to serve in an advisory capacity to the armed services and other government agencies, is composed of the following eminent scientists, industrialists, inventors, members of the armed services, and the Commissioner of Patents, all of whom lend their specialized knowledge and experience to the council without compensation: chairman: Dr. Charles F. Kettering, vice-chairman: Dr. Oliver Buckley, secretary: Lawrence Langner, Dr. George Baekeland, Watson Davis, Dr. Frederick M. Feiker, Dr. Roger Adams, Maj. General James McCormack, Jr., Dr. Hugh L. Dryden, Maj. General John F. Uncles, Homer Ewing, Dr. William D. Coolidge, Dr. George W. Codrington, Hon. Robert C. Watson, Rear Admiral Frederick R. Furth, Luis de Florez, Dr. Webster Jones, James C. Zeder, Dr. Alvan Barach, Dr. Thomas Keith Glennan, Brooks Walker, and Henry J. Rand.

All correspondence should be addressed to: The National Inventors Council, U. S. Department of Commerce, Washington 25, D. C.

Sperry Gyroscope Employs X-Ray for Development Problems

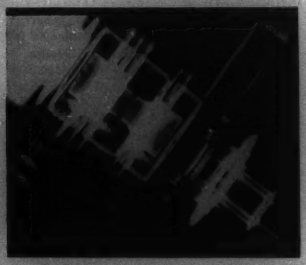
In a remote section of Sperry Gyroscope Company's plant at Great Neck, Long Island, N. Y., a specialized group of technical experts carry a heavy responsibility in solving development and production problems.

The department under discussion is the materials laboratory of the engineering division and its metallurgical section where the modern Norelco-Philips X-ray radiographic installation is located.

The radiographer is faced with a large variety of problems transmitted to him by engineers. Frequently, X ray is used to check models where radiographic details must be much better than is possible with ordinary commercial equipment. Fine grain film is employed, and critical alignment of objects is assured through use of a scale level and a specially designed precision pointer that is free of wobble.

Many microwave components must be held to close tolerances. For example, one waveguide assembly is made by precision

(Left) Squirrel cage stator for marine gyro compass is slid onto the working end of the Philips MG 150 rod-anode X-ray tube. The film in the foreground is then wrapped around the rotor and the X-ray exposure records all details around the unit's circumference. (Insert) Radiographs show old and new method for X raying squirrel cage rotors; top film was made with Philips rod-anode tube showing all rotor bars on one exposure. Previously, 24 separate films (one illustrated) had to be made, one for each bar. Detail was much poorer. Fig. 2. (Right) the radiographer positions a large electron tube, the SAL-39 klystron, under the port where the X-ray beam emerges from the Philips MG 300 tube



Interior of the 20-inch SAL-39 klystron, vital for air navigation, is revealed in excellent detail when radiographed with the new Philips MG 300 tube

casting methods. Internal measurements must be kept to two or three thousandths. Without special X-ray equipment, it would be difficult to check these dimensions.

Engineers depend on radiographs to reveal internal conditions of many sealed-in mechanisms, before and after life tests. For example, in the case of relays, the devices are examined for contact trouble and mechanical failures.

Large and small electronic tubes, including microwave klystrons varying from 2 inches to 8 feet in length, are also radiographically inspected. One such tube is the 20-inch *SAL-39* klystron, vital for air navigation and other systems. Similarly, the small *2K25* klystron is X-rayed for defects. This tube plugs into a standard octal base socket and is approximately the same size as a standard metal-envelope receiving tube.

In general, klystrons and other electron tubes are radiographed to discover damaged grids, misaligned cathodes, bad spot welds, improperly spaced antenna loops, and displaced coaxial leads. In addition to tubes, the laboratory also X rays coils of standard coaxial cable and a number of other purchased materials.

The radiography equipment is installed in a medium-sized room lined with approximately 7½ tons of lead. The control console is outside the enclosure, opposite a lead-glass window that provides a view of the interior. The X-ray unit has one 150-kv rod-anode tube, one 150-kv double fractional focus tube, and one 300-kv tube. This equipment is a recent Norelco development and the Sperry installation is among the first to go into operation in the United States.

The 150-kv rod-anode tube recently solved an interesting problem. In developing squirrel-cage stators for marine gyro-compass installations, the conductor bars were centrifugally cast from copper. When the finished stators were examined, it was found that the copper not only filled the slots as intended but in some cases also seeped between iron laminations, thus short circuiting the bars.

Before the new *MG 150/300* equipment was installed, Sperry had to make 24 X-ray exposures on each assembly taking 8 minutes each. Radiographing one assembly took 192 minutes plus setup time. Now the assembly is slipped onto the *MG 150* rod-anode tube, a film is wrapped around the exterior, and the entire job is finished in 6 minutes. Instead of having to sort and co-ordinate 24 separate films for one assembly, the present procedure produces a film strip showing all bars properly related. Film grain can now be finer, and details are much sharper than was possible with previous equipment and technique.

The small 2K25 klystron, approximately the size of a standard receiving tube, is shown here radiographed with the Philips 150-kv double fractional focus tube

Opportunity for Training in Nuclear Reactor Engineering

Industrial firms interested in obtaining competent reactor engineers who know the details of the most recent advances in nuclear reactor technology are invited to sponsor engineers and scientists in their employ for enrollment in the 1955–56 session of the Oak Ridge School of Reactor Technology at Oak Ridge, Tenn. The deadline date for applications is March 14, 1955. The 50-week course of study begins September 12, 1955. To defray the prorata operating costs of the school, including all supplies and the use of special facilities, a fee of $2,500 is charged for each student. For those who are on an U. S. Atomic Energy Commission cost-type contract or government payroll there is no charge.

The school is part of Oak Ridge National Laboratory, which is operated by Union Carbide and Carbon Corporation for the Government. At the laboratory large research facilities such as working reactors are used as part of the student's training.

One of the critical factors which will determine the rate-of-growth of the nuclear reactor industry in the next few years is the supply of competent reactor engineers. The majority of the problems encountered in the field of nuclear reactor engineering involves the engineering and management skills which are well established in industry. The school offers an excellent opportunity for able engineers and scientists who have an adequate grasp of basic science and engineering to obtain the training needed to broaden the scope of their competence into new areas of technology essential for dealing effectively with problems of design of a nuclear reactor complex. Sponsored students remain on the payroll of their home organizations and, upon returning after completion of the course, can be expected to play a key role in strengthening their company's technical position for competing in the rapidly growing atomic energy industry.

The school utilizes the laboratory's staff and facilities for the instruction of students. Much of the material presented in the curriculum of the Oak Ridge School of Reactor Technology is classified, so enrollment is contingent upon satisfactory completion of a personnel security investigation.

Further information and application forms may be obtained from the Director, Oak Ridge School of Reactor Technology, Oak Ridge National Laboratory, P. O. Box P, Oak Ridge, Tenn.

National Manpower Council Studies Skilled Workers

Serious shortcomings in the education, guidance, and training of the nation's skilled manpower were cited by the National Manpower Council recently as evidence that any complacent attitude about the superiority of America's technical know-how is "short-sighted and dangerous."

In its third major manpower report, the Council warned that both our economic progress and future security depend upon improving the quality and supply of skilled workers and technicians. The Council's pioneering study describes the skilled group as that "vital segment of our manpower whose formal education usually stops with high school or junior college." It estimates there are already between 8- and 9-million workers in this category who provide most of the nation's services and play a critical role in the production of nearly half the world's goods.

This investigation is highlighted by 20 specific recommendations for action by employers, unions, local and state governments, educators, school boards, the President, Congress, the Secretary of Defense, universities, and foundations. The Council warned that the development and effective utilization of manpower resources can no longer be left to chance. "Our present position and future needs," the report said, "require that we concern ourselves with the long-range development and effective utilization of all our trained manpower resources."

A 300-page report published in book form by the Columbia University Press under the title, "A Policy for Skilled Manpower," was founded on the basis of a 2-year study. The report listed five major long-range objectives: to strengthen the contributions made by secondary education to the acquisition of skill; to develop a more effective program for vocational guidance; to provide more equal opportunities for all individuals to acquire skill; to improve the facilities and methods used to train skilled and technical manpower; and to increase knowledge about our manpower resources.

The National Manpower Council was established in 1951 at Columbia's graduate school of business by President Eisenhower, then head of the university, through a Ford Foundation grant to provide a continuing appraisal of the nation's manpower problems in a period of enduring emergency. Its membership includes 16 distinguished private citizens from all parts of the country. The Council's purpose and studies are given in a 48-page booklet, "A Report on the National Manpower Council," published by the Columbia University Press.

Better Science Teachers' Training Urged by Manpower Commissions

More than 100,000 students in the nation's high schools last fall enrolled in mathematics and science classes presided over by inadequately trained teachers. The danger to the future of the country's technology and to its national security in the serious shortage of properly prepared teachers was emphasized in a statement issued recently by the Engineering Manpower Commission (EMC), New York, N. Y., and the Scientific Manpower Commission (SMC), Washington, D. C.

The statement of the commissions follows a recent report of their Joint Committee on High School Teachers of Science, which has been engaged in a survey of conditions and in a study of means of correcting the situation and alleviating the shortage of science teachers and of assuring their proper training.

The two commissions have been the more concerned over the shortage of students and properly prepared teachers in these fields because, while United States education has been falling behind in these respects, Russia has been placing increasing emphasis on engineering and science in its education program and has enrolled in recent years a tremendous number of students of technology.

The EMC-SMC statement said in part:

"The professional engineering and scientific societies of the United States, which have been calling attention for some time to the shortages of manpower in these fields, now find it necessary to emphasize the most acute shortage of all, the shortage of adequately trained high school teachers of science and mathematics.

"There are many well-prepared teachers of science and mathematics in our high schools. But, apart from these, there also

Future Meetings of Other Societies

The American Society of Mechanical Engineers, First International Congress on Air Pollution. March 1–2, 1955, Hotel Statler, New York, N. Y.

National Association of Corrosion Engineers, Eleventh Annual Conference and Exhibition, March 7–11, 1955, Palmer House, Chicago, Ill.

Oklahoma Agriculture and Mining College, Symposium on Electromagnetic Relays. March 9–11, 1955, Stillwater, Okla.

National Electrical Manufacturers Association, Meeting. March 13–18, 1955, Edgewater Beach Hotel, Chicago, Ill.

Steel Founders' Society of America, Annual Meeting. March 14–15, 1955, Drake Hotel, Chicago, Ill.

American Society of Tool Engineers, 23rd Annual Meeting. March 14–18, 1955, Los Angeles, Calif.

Association of Supervising Electrical Engineers, Fourth Electrical Engineers' Exhibition. March 15–19, 1955, Earls Court, London, England.

Southeastern Electrical Exchange, Annual Meeting. March 21–23, 1955, Boca Raton Hotel, Boca Raton, Fla.

Institute of Radio Engineers, National Convention. March 21–24, 1955, Waldorf-Astoria Hotel, New York, N. Y.

American Society for Metals, Western Metal Expo and Congress. March 28–April 1, 1955, Pan-Pacific Auditorium, Los Angeles, Calif.

Society for Nondestructive Testing, Ninth Western Metal Congress. March 28–April 1, 1955, Hotel Ambassadore, Los Angeles, Calif.

Illinois Institute of Technology, 17th Annual American Power Conference. March 30–April 1, 1955, Sherman Hotel, Chicago, Ill.

Radio Technical Commission for Aeronautics—Institute of Radio Engineers, Los Angeles Section, Spring Assembly Meeting. April 5–7, 1955, Los Angeles, Calif.

The American Society of Mechanical Engineers, Machine Design Division and New York Metropolitan Section, National Machine Design Conference. April 6, 1955, New York University, University Heights Campus, New York, N. Y.

Society of Plastics Industry, Pacific Coast Section Conference. April 13–15, 1955, Palm Springs, Calif.

American Ordnance Association, Proving Ground Instrumentation Committee, Symposium. April 14–15, 1955, Patrick Air Force Base, Eau Galli, Fla. Security Classification: Secret.

The American Society of Mechanical Engineers, Spring Meeting. April 18–20, 1955, Lord Baltimore Hotel, Baltimore, Md.

Stanford Research Institute, Third National Air Pollution Symposium. April 18–20, 1955, Huntington-Sheraton Hotel, Pasadena, Calif.

Agricultural and Mechanical College of Texas, Eighth Annual Conference for Protective Relay Engineers. April 25–27, 1955, College Station, Tex.

Institute of Radio Engineers, Boston and Connecticut Valley Sections, New England Radio-Electronics Meeting. April 29–30, 1955, Sheraton-Plaza Hotel, Boston, Mass.

have been registered this fall more than 100,000 students in high school science and mathematics classes who are being taught by teachers who have not been trained adequately. This confronts the nation with a dangerous situation in its need of able technologists not only in time of peace but also in contributing to the assurance of the national security against any possible future aggression.

"There now is a high school influx of students. The need for more teachers is evident. Teachers in the 9th to 12th grades require more training than teachers in the lower classes. As teachers do obtain better training, they find that their improved preparation qualifies them for outside jobs that pay higher than teaching. In consequence, only half the young men and women who earn teaching certificates in science and mathematics actually teach.

"The EMC and the SMC believe the problem is one the schools should not have to face alone. The joint committee of the two commissions has proposed an action program for their constituent professional engineering and scientific societies.

"The committee urges engineers and scientists in industry to advise high school teachers and to provide summer jobs that will give them realistic experience in their specialties and, in addition, will assure them needed earnings. College authorities are urged to promote high school teaching as a career and to provide more courses for teachers.

"Professional societies are asked to assist in setting up conferences, institutes, symposia, fellowships, and other activities that would improve the ability of teachers. They are advised to assist in arranging plant and laboratory visits by teachers and students and in obtaining adequate libraries and laboratory facilities. Societies and their members are encouraged to promote and participate in guidance services for high school students, in which the requisite qualifications and the opportunities for, as well as the advantages and difficulties of careers in engineering, science, and science teaching, are presented realistically."

Ultrasonic Device Probes Materials for Development of Defects

For some time, scientists have been probing into the interior of materials much as a doctor seeks to uncover causes of critical diseases arising in the vitals of the human body. Armed with knowledge of the interior structure in a given material, they can virtually anticipate how such material will perform at future intervals. In other words, it might be said that they can predict the history of a material's life in advance.

Making nondestructive test with ultrasonic attenuation analyzer

The importance of establishing such techniques is illustrated by the high priority investigation conducted by British experts into the mysterious crashes of two Comets, the most advanced jet air transport craft designed at the time, with which England had hoped to take the lead in airplane development. Preliminary reports were that metal fatigue under various stresses caused destruction of the craft in midair.

At Vibro-Ceramics Corporation, a Gulton Industries affiliate in Metuchen, N. J., an instrument has been developed that exposes the inner secrets of many materials, comprising most solids and some liquids, with precise accuracy. Termed an ultrasonic attenuation analyzer, it enables one to determine internal changes of structure where no apparent changes show on the surface, or detect flaws and irregularities inside that can make the difference between good and bad performance of such materials. The ultrasonic device works well over a wide range of frequencies. The pulse duration should be at least 5 or 6 times the period of the carrier frequency.

The analyzer operates by placing a small transducer against the material to be tested. The transducer, which converts an electric current into mechanical energy, beams a short ultrasonic signal through the material. The analyzer then records the return pulses reflected by the material for comparative information. Several sets of information are obtained, the three most important of which are: the attenuation of the ultrasonic signal; its characteristic velocity; and the shape of the reflected pulses. All this information can be derived from observing the pattern on a cathode ray tube.

The ultrasonic analyzer permits comparison with the data obtained from other similar materials of a fixed or known standard. Any discrepancies will indicate the presence of interior differences between the two materials compared.

One of the advantages of sound waves over electromagnetic waves, such as Xrays, lies in the fact that the former are influenced far more decidedly and more accurately by internal structure in large material samples where nondestructive testing methods are employed. Many defects cannot be detected by electromagnetic waves at all. The X-ray absorption is a function of mass traversed and does not enable the investigator to discover very thin flaws and cracks. Such flaws, on the other hand, have a substantial effect on propagation of ultrasonic waves.

However, in its development to date the attenuation analyzer has several basic limitations. The sample for testing must have flat and parallel faces; this is necessary in order to establish proper contact for the transducer and to provide a clear reflection of the pulses. The sample must be sufficiently thick, at least 1/4-inch thick, to prevent the leading edge of the ultrasonic pulse from overlapping its own trailing edge at the input boundary or surface; the latter situation would produce a confused signal on the cathode tube. Finally, in making comparative tests, the samples and reference standard must be reasonably similar in size and shape in order to establish valid conclusions.

New Long-Distance Waveguide Is Flexible Copper Tube

A new and radically different medium for transmitting television and telephone conversations over long distances has been used successfully in experiments, Bell Telephone Laboratories announced recently. The new medium, a long-distance waveguide, is markedly different from modern cable or radio relay systems—it uses hollow metallic tubes roughly 2 inches in diameter.

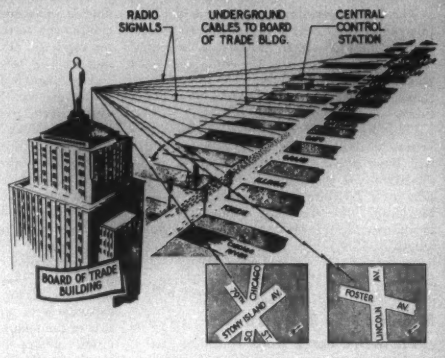
Bell scientists believe the new waveguide may someday simultaneously carry tens of thousands of cross-country telephone conversations along with hundreds of television programs. Top capacity for the most modern of coaxial cable systems is 1,860 2-way telephone conversations or 600 such telephone conversations and two television programs simultaneously on a pair of coaxial tubes. Modern coaxial cables have eight such tubes, two of which are kept as spares for emergencies.

This hose-like tube is the Bell Telephone Laboratories' new long-distance waveguide, a radically different means for transmitting television and telephone conversations. The flexible copper tube channels radio waves any way it is bent, and may some day make possible simultaneous transmission of tens of thousands of cross-country telephone conversations and hundreds of television programs over the same electric pathway. Here, scientists examine wood forms used in testing transmission around curves

Waveguides made of solid metal tubing have been widely used for some time for short distances. It would be possible to use these solid metal tubes for long distances if they were perfectly straight, but this is impractical. The new long-distance waveguide is also a hollow tube, but it is constructed of a thin copper wire, very tightly coiled—like a spring under pressure—and wrapped inside a flexible outer coating which holds the coiled wire in place. This type need not be straight and can actually carry signals around corners.

Experiments indicate that both the solid-tube type waveguide and the new coiled wire or "helical" type of waveguide can be used together in communications systems. Although this new form of transmission is still in the experimental stage, a recent long distance test was made at Bell's Holmdel, N. J., laboratory in a copper pipe, 500 feet long. Engineers bounced signals back and forth in the tube for distances of 40 miles. They calculated that, in comparison, the same waves could have traveled only 12 miles in a coaxial cable with the same loss in strength.

The new transmission system operates in a frequency range so high that it has never before been put to practical use for communications. As a matter of fact, this range is so high that engineers do not have a name for it yet although the short waves used are known as "millimeter waves". The super-high-frequency range established by the Federal Communications Commission goes up to 30,000 mc; the carrier frequency for the new waveguide is about 50,000 mc. A major difference between transmission through the new waveguide and through previous systems is that the higher the frequency in the waveguide, the less the loss through attenuation. This is exactly the reverse of other forms of transmission.



System for traffic control by radio in Chicago

New Traffic-Light System to Be Radio Controlled

The General Electric Company announced recently that it has received a contract to design, develop, and manufacture a radio-controlled traffic-light system for the city of Chicago.

The electronic system, the first of its kind in the world, will be used to control traffic signals in a heavy traffic area just north of Chicago's Loop. Initially, traffic lights at 13 intersections will be radio controlled. The system features the use of electronic tones which are transmitted by FM radio, like that widely used by fire and police departments.

According to Chicago's traffic engineer, Ralph Michel, the cost of installing conventional means of controlling the traffic signals was prohibitive. After several years of intensive investigation, it was found that radio control would be much less expensive. In addition, the necessity of laying underground cable with accompanying torn up streets and inconvenience to traffic is avoided. The initial contract approximated $34,000. It is expected that the equipment will be installed and operating within the next 6 months.

The radio antenna and transmitter for the new system will be located on top of the Board of Trade Building, the highest point in Chicago. The central control station, which will be located a short distance away in City Hall, will be connected to the transmitter by an existing underground cable.

At predetermined times each day, a master mechanism in the central control station will activate a tone signal. The signal will be carried by the underground cable to the transmitter and broadcast to the lights. In the receiver, at each intersection that the signal is intended to control, will be a corresponding tone switch, or decoder. Each decoder will select the signal designed for its intersection, and ignore those intended for other intersections.

The corresponding tone switch in the traffic light control box at the intersection will respond to the received tone signal by changing the program (the length of time of green, yellow, and red) of the traffic light. Each change of program will be accomplished in a fraction of a second.

In addition to predetermined program changes accomplished automatically, the radio controls can be operated manually. This will allow the programs of the traffic lights to be operated in the most desirable sequence during an abnormal condition such as bad weather.

This will be the world's first system of this type for controlling traffic lights by radio, according to Harrison VanAken, General Electric's general manager of communication equipment. He said the General Electric Company has designed, developed, and installed many other similar electronic tone systems. Among these are remote electronic systems for sounding air raid and fire sirens, radio relay equipment for reporting river level information in flood sensitive areas, and control systems for remotely operating oil-line pumping stations and oil-line valves.

Plans Made for Constructing Jet Engine Research Center

Plans to build new jet engine research and development facilities costing more than $12\frac{1}{2}$-million dollars have been announced by Westinghouse Electric Corporation. The expansion program was announced by W. W. Smith, manager of the Westinghouse Aviation Gas Turbine Division, Kansas City, Mo.

The new facilities, which include both high- and low-power laboratories and an experimental engineering shop, will be located at the present site of the huge jet engine plant south of Kansas City. A portion of the more than 230,000-square-foot laboratory will be made available within the confines of the existing 80-acre building. The high-power and fuel-testing laboratories will be constructed adjacent to the present structure.

The new laboratories will provide for research and development testing on components of new jet engine designs, and for development of improvements in existing jet engines. The experimental shop will manufacture newly designed components, as well as complete experimental engine models.

"The need for more rapid development of turbojet aircraft engines has accented the necessity for immediate expansion of Westinghouse development facilities," Mr. Smith said. "The addition of these facilities will be another step forward toward a completely integrated jet engine research, development, and production center at our Kansas City plant."

Miniature Lamp Designed for Use on "Hot" Appliances

Development of a revolutionary new type of miniature lamp to be used for indicating purposes on "hot" appliances was announced by General Electric Company's Lamp Division, Cleveland, Ohio. The lamp consists of a small glass bubble sealed around a coiled filament, with two rigid pins protruding at the base.

Because it will withstand temperatures twice as high as conventional miniature lamps (600 F versus 350 F), it is expected to find wide use on such appliances as waffle irons, electric casseroles, broilers, fryers, flat irons, toasters, and others where indicator lamps have been impractical or costly before. Indicator lamps show whether an electric appliance is turned off or on.

Lamp designed for "hot" appliances

The lamp's terminals, or pins, will plug into appliance sockets in much the same manner that an electronic tube is inserted in a radio receiver. For the convenience of socket manufacturers, the pins are of the same size as those on miniature electronic tubes.

Of more rugged construction than conventional miniature lamps, the new bulb will have greater resistance to shock and vibration. It is being made available at first in a 2.5-volt, half-ampere, 3,000-hour life lamp. The tiny bulb is only 7/16-inch in diameter, and has a maximum over-all length of 15/16-inch.

Mobile Radio Relay Tower for Short Term Use

Facilities for the transmission of video signals by wire or microwave radio relay are many times a necessity. Wide-band local channels may be from the point of origination of the video signal to the broadcaster's studio, from the studio to the transmitter, or between the studio and the intercity network.

The local channels from the point of origination are frequently installed for a period of short duration, sometimes for a single show lasting 15 minutes or less. When microwave radio relay equipment is used for this service it may become necessary to erect a tower to provide clearance over terrain, buildings, trees, etc. The cost of conventional structures, such as steel towers or temporary scaffolding is sometimes considered prohibitive for short term use. Other problems which may preclude the use of a tower include those attendant to zoning ordinances, building codes, etc. The nature of much of the programming in the highly competitive television field is such that adequate notice for overcoming the various legal obstacles often cannot be given. Furthermore, space for guying and erecting towers is not always available.

Microwave radio relay tower

The Chesapeake and Potomac Telephone Company recently was given an order to provide a short-term local channel from a residential location in Washington, D. C. The erection of a tower would have been impracticable for several reasons. Surveys indicated that approximately 90 feet of elevation would be required to clear obstructions. It was decided to make use of a truck-mounted portable crane to provide the required antenna height.

A 5-foot steel crossarm was bolted to the top of the 90-foot crane boom. From each extremity of the crossarm a 2,200-pound-capacity steel messenger was strung to the rear of the telephone company's mobile television pickup unit. The antenna was mounted on a carriage which was adapted to be winched up and down and guided by the two strands. As is well known, the extremities of a tightly stretched messenger are quite rigid, although there many be considerable movement mid span. Since the antenna was to be used at the top of the strand, it was satisfactorily rigid. The orientation of the parabolic antenna was accomplished by remotely controlled motors.

It was found that a microwave radio relay transmitter or receiver antenna could be erected and ready for service in less than an hour after the arrival of the crane on the job, if the crane can be transported through the streets with the boom assembled. The cost of hiring the crane was about one-third of the cost of erecting and guying a portable steel tower.

Compact Electronic Equipment Introduced for Small Craft

The Radiomarine Corporation of America recently introduced its newest radar, loran, radiotelephone, and depth recording equipment.

A new radar, model *CR-105*, offers maximum performance and space-saving compactness at a low cost. It is designed for fishing craft, tugs, ferries, or any vessel on which space and power supply are limited. Two basic units, the indicator and antenna, comprise the new set. The indicator is a compact, deck-mounted binnacle weighing 130 pounds and requiring less than 2 square feet of deck space for mounting. It can be set on 1 4 16-mile ranges, has a minimum range of 50 yards, and can be calibrated for nautical or statute miles, as specified. There is an easily readable 10-inch scope, and operating controls are illuminated.

The antenna weighs 110 pounds and is mechanically robust. It is designed to provide a horizontal beam width of 1.9° and a vertical beam width of 20°. The reflector and horn assembly at the top of the unit rotate at a speed of approximately 20 rpm. An aluminum watertight enclosure, below the reflector and horn assembly is provided with two gasketed doors. These permit easy access to the electrical parts mounted inside, such as the antenna drive motor, synchro, receiver preamplifier, magnetron, TR and anti-TR tubes.

Features of this model include: separate power converter for d-c ships or voltage regulator for a-c ships; 3.2-cm band; 7-kw peak power; broad 20-degree vertical beam to offset the roll and pitch of the ship in rough weather; no waveguide needed; and it requires only 600-watts drain from ship's battery or other d-c power supply.

Loran indicator-receiver for installation aboard small craft

The new Radiomarine loran, model *LR-8803*, is especially suitable for installation aboard passenger and cargo ships, tankers, and fishing craft. It features a large direct-reading time difference dial; "ruggedized" tubes; 2-speed time difference adjustment from single control; ultraviolet panel light; table, overhead, or bulkhead mounting; lightweight—indicator weighs less than 45 pounds; automatic frequency control; self-checking for instant verification of instrument operation; and interference reducer for spurious signals.

The Radiomarine loran indicator unit which houses the receiver, indicator, and timer circuits is contained in a metal cabinet. The cathode-ray oscilloscope and all operating controls are grouped on the front panel of the instrument. Ultraviolet light on the front panel allows one to read controls easily at night. The panel and chassis assembly are mounted on tracks and may be withdrawn for servicing. The external power supply is a separate rectifier unit used to supply the proper voltages to all "ruggedized" indicator tubes.

New, also, is the radiotelephone, model *ET-8057*, power rated at 100 watts, as defined by Federal Communication Commission regulations. Its 8 crystal-controlled transmitting and receiving channels have a range of 2,000–3,000 kc to cover harbor radiotelephone and intership frequencies.

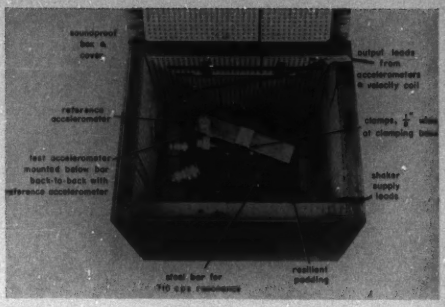
It has such features as an output booster and indicator for maximum antenna power at all times; front-panel control for squelch circuit which eliminates annoying static during stand-by; easy-to-read meter to indicater correct tuning of transmitter; large 4- by 6-inch loudspeaker; functional control grouping; all-aluminum construction; low battery drain; transmitter ON-OFF switch to minimize drain while standing by for a call; low harmonic output. The set operates on 12, 32, or 115 volts d-c, or 115 volts a-c.

Another new piece of equipment is the echograph—a sturdy 3-range depth recorder for use on fishing boats and pleasure craft. Its ability to indicate fish makes it a "must" for fishermen. By accurately recording depth and warning of rocks, wrecks, and other underwater hazards, it serves as an invaluable aid to the navigator. Its 3 ranges (0–180, 180–360, or 360–540 feet) provide continuous indications of conditions

below the ship on a large clear dry paper chart.

The echograph operates on the echo-sounding principle (measuring water depth by determining the length of time sound waves travel from surface to bottom and return). It produces the sound waves, receives and amplifies the returned echoes, measures the elapsed time, and presents these measurements in the form of a continuous graphic record, which is burned into a sensitive paper coating by a voltage through the stylus.

This instrument utilizes the method developed for the steady-state calibration of vibration pickups and accelerometers at high values of acceleration. A steel bar with a vibration pickup clamped to one end is driven at its resonant frequency at acceleration up to 1,090 g


soundproof box & cover
output leads from accelerometer & velocity coil
reference accelerometer
clamps, ½" wide at clamping base
test accelerometer mounted below bar back-to-back with reference accelerometer
shaker supply leads
steel bar for 710 cps resonance
resilient padding

Pickups and Accelerometers Calibrated by New Means

In recent years the widespread use of vibration pickups has introduced a serious calibration problem. The increase in the number of pickups has emphasized the need for rapid and reliable means of calibration over wide ranges of frequency, amplitude, and acceleration. Several methods which are proving useful in the accurate calibration of vibration pickups and accelerometers have recently been developed at the National Bureau of Standards (NBS) in connection with a program of basic instrumentation research sponsored by the Office of Naval Research, the Air Research and Development Command, and the Atomic Energy Commission. In one method, a "chatter" accelerometer determines very accurately the peak value of a sinusoidal acceleration, when this value is slightly in excess of 1 g. The device is useful in setting the acceleration level of vibration generators which are used in the calibration of vibration pickups. In another method, a steel bar is mounted on a conventional vibration generator. A vibration pickup is attached to one end of the bar, and the system is driven at its resonant frequency. Use of the resonance effect achieves values of acceleration up to 1,090 g—much higher than would be attainable if the pickup, without the steel bar, were mounted directly on the same type of shaker.

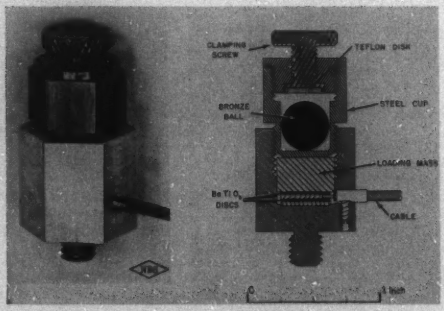
The "chatter" principle was first described by Sir William Bragg in 1919. The accelerometer based on this principle is a device in which a loose mass on a vertically vibrating surface bounces or "chatters" when the peak acceleration of the sinusoidal motion exceeds ±1 g. Using an improved accelerometer developed by C. W. Kissinger of NBS, the acceleration of the shaker table to which the device is attached, as well as the chatter of the loose mass, are converted into an electric signal which is displayed on the screen of an oscilloscope. The mathematical relationship was also derived between the amount by which the peak value of the sinusoidal acceleration exceeds 1 g, and the point in the cycle at which the first bounce occurs. If this mathematical relationship is applied to the accelerometer output as observed on the oscilloscope screen, acceleration levels from about 1.01 g to 1.04 g may be set with an accuracy of approximately 0.2 per cent at frequencies up to 60 cps, and with somewhat decreased accuracy up to 150 cycles per second. Accuracy of calibration was estimated by comparison with an optical calibration in which the peak-to-peak displacement of the chatter accelerometer was measured with a micrometer microscope. Stroboscopic illumination makes the accelerometer appear to be nearly motionless for ease of measuring displacement.

In the Bureau's chatter accelerometer, the loose mass can be clamped by a screw and prevented from chattering. The accelerometer can then be used as a secondary standard for accelerations in excess of 1 g at frequencies up to 1,200 cycles per second.

The method for steady-state calibration at high values of sinusoidal acceleration was developed by T. A. Perls and C. W. Kissinger of the NBS staff. In this method, a steel bar is clamped to the head of an electrodynamic shaker at its center point, so that both ends of the bar are free. The accelerometer being tested is clamped back-to-back with an *NBS-33-14* secondary standard accelerometer at one end of the bar, and a balancing weight is fastened to the other end, if needed. The whole system is driven at its resonant frequency by a 70-watt amplifier. Steady-state accelerations have been measured with this system up to 1,090 g, zero to peak, 874 cycles per second. When the resonant bar was additionally loaded with a 40-gm test accelerometer, accelerations up to 665 g were attained. In comparison, if the steel bar had not been used and the accelerometer had been mounted directly on the shaker head, the maximum attainable acceleration would have been only 50 g.

A series of tests was conducted at the Bureau in which the steel bars used as part of the resonant system were first tested in the annealed state, and then heat-treated and again tested. Results indicate that the heat treatment increases the maximum steady-state acceleration two-fold. In most cases the vibrational amplitude did not remain proportional to the shaker excitation current over the full available power range. Thus, the elastic properties of the bars used in the tests limit the maximum steady-state vibratory amplitudes attainable by this method.

In this method, the armature of the electrodynamic shaker is part of the resonating system, and its amplitude of motion at resonance is proportional to the amplitude at the ends of the bar. This mode of operation makes it possible to determine that the output of an *NBS-33-14* accelerometer from 25 to 1,090 g at 874 cycles per second is proportional, within 2 per cent, to the output of a velocity pickup built into the armature of the shaker.



The NBS-33-14 chatter accelerometer determines very accurately the peak value of a semisoidal acceleration when their value is slightly in excess of 1 g

Radiation Monitoring System for Use in Atomic Tests

The National Bureau of Standards (NBS) has developed a remote-control system which automatically measures radiation intensities and other variables in the vicinity of an atomic explosion, and transmits the data by radio to a centrally located headquarters. The system was designed at the request of the Division of Biology and Medicine of the Atomic Energy Commission for use in nuclear tests. Though developed specifically for monitoring gamma radiation and weather conditions, it can be used with

Schematic drawing of the remote-control system developed by the National Bureau of Standards for monitoring radiation produced by an atomic explosion. Repeater stations at elevated positions permit communication at vhf between the central control station (lower right) and the various data stations distributed about the center of the explosion

a wide variety of detectors to report many types of information. Except for the control station, the entire system is battery powered and will operate unattended for long periods.

The over-all design of the NBS radiation monitoring system was worked out by L. Costrell, G. Minton, and E. R. Saunders of the Bureau's nucleonic instrumentation laboratory. It permits the operator at the control station to select one of several data stations for transmission of data and to determine what particular type of information is to be reported. The radio link and the station interrogation system were designed and constructed by the Motorola Corporation and are based largely on their 1/4-watt portable transmitter-receiver and other standard equipment.

The radio link is an FM system operating in the vhf band between 162 and 174 mc. Since line-of-sight transmission is required, the link employs repeater stations located at positions of high elevation. Each repeater can handle information from 10 data stations, and each data station offers a choice of ten different programs—each having several functions—which the operator can select for transmission to the control station. Thus, for example, one program might consist of station identification, several calibrations, and radiation intensity readings, while another program might contain weather information.

Battery power is conserved by means of cycle timers at the repeater and data stations. The cycle timers operate in conjunction with a coder unit in the control station, which enables the control station operator to select the desired repeater and data stations. The cycle timers regularly turn the receivers at these stations on for 2 seconds out of every 20. If during the "on" part of the cycle the coder unit sends out a properly modulated signal indicating that the control station desires to communicate with a particular repeater or data station, the receiver at this station will be locked on and will no longer be controlled by the cycle timer. As cycle timers are installed at both repeater and data stations, the control station must transmit its coded signal for approximately 40 seconds in order to be sure to "capture" the repeater station and to have the repeater capture the data station.

After the repeater and a data station have been captured, the control station operator can then direct the data station to transmit the desired program of information. He does this by dialing the proper program number on the control console, which serves to energize the transmitter and modulator at the data station. The data station then transmits the desired program through the repeater to the control station. The information is transmitted in the form of a variable frequency covering the range of about 750 cycles per second to 4 kc. At the control station this audio frequency is fed to a frequency counter, where it is counted and displayed in alternate 1-second periods and also printed on a digital recorder. Calibration curves of radiation intensity or other quantities as a function of frequency are utilized in interpreting the frequency variations in terms of the measured data.

After the program has been completed, the data station receiver remains active for a short period, ready to accept further program challenges. The equipment is then automatically de-energized, and the cycle timer again assumes control, activating the receiver 2 seconds out of every 20.

Army Discloses Development of Radar Mortar Locator

A vital new use of radar in ground combat to detect and track down the source of enemy mortar fire, was disclosed recently by the Department of the Army. The Army also revealed that American ground forces in several theaters already are equipped with the electronic mortar locator systems.

Known as counter-mortar radar *AN/MPQ-10*, the device was jointly developed and designed by the U. S. Army Signal Corps and the Sperry Gyroscope Company. With the aid of this new electronic locator, frontline forces can detect and "lock on" the path of enemy mortar shells, automatically track their trajectory, and reveal the enemy position.

These co-ordinates then are relayed to an Artillery Fire Direction Center, which responds with precisely-aimed fire to eliminate enemy mortars within moments after they open fire. Hundreds of soldiers now returned safely from Korea literally owe their lives to the extreme accuracy and speed of the new counter-mortar system, the Army said.

The equipment is compact and mobile, and can be towed by a light Army truck for quick movement in battle. The system consists of a large automatic radar tracker with dish-shaped antenna, a gasoline motor generator of Signal Corps lightweight design, a portable tracker mount resembling a 40-mm gun carriage for rapid movement to new positions, and a separate remote-control console with radarscopes and all controls used during operation of the radar set.

The modified gun carriage mounts six major components of the radar system, including elevation and range computers. Extension cables permit operators to work the set from positions remote from the large automatic tracker, which tilts up or down and rotates in all directions for continuous search. One radar officer commands the skilled operations team who translate radar plot to precise coordinates for artillery counterfire. Their portable control unit is about the size of a large-screen home television set, and can be readily concealed in protected dugouts, trenches, or foxholes.

Silicon Carbide Grain Used in Telephone Circuit Controls

"Traffic Cops" in a telephone circuit? That is precisely what Western Electric Company's Indianapolis, Ind., plant manufactures with the aid of a special Crystolon silicon carbide abrasive grain made by Norton Company, Worcester, Mass.

These "traffic cops" are technically referred to as varistors, a contraction of the term "variable resistor." They are used to control the flow of current to the transmitter and receiver of a telephone. If the telephone is installed on premises distant from the central office where the connecting circuit is long and causes considerable loss to the transmitted voice signals, the flow of battery current is small. In this condition the varistors are high in resistance and allow the transmitter and receiver to operate at maximum efficiency. On premises near the central office, however, the circuits are short, the battery currents are high, and the circuit losses small so that maximum performance would reproduce speech at uncomfortably high levels. The varistors in this high-current condition are low in resistance and by-pass some of the voice signal. This introduction of compensating loss, where needed, makes the loudness of telephone speech less dependent on the location of the telephone station and more uniform and acceptable to the telephone subscribers.

The varistors are in the form of discs which are pressed from a mixture of silicon carbide crystals, graphite, clay, and water. After pressing to the required thickness—0.023 inch to 0.035 inch—they are fired at temperatures of 1135 to 1250 C. Molten copper is then sprayed on both sides to form electrodes and in the final step, terminals are soldered on either side. These varistors are being installed in telephone sets at a rate of 5 million per year.

The critical element in this varistor disc is the silicon carbide. The grain is made to conform to rigid electrical requirements. A method for producing this special silicon carbide was developed by engineers of the Bell Telephone Laboratories. Norton Company engineers adapted this method to commercial productions techniques. Although best known as an abrasive, silicon carbide is also widely used as a refractory

material. More recently, its electrical properties have been exploited in the development of lightning arrestors for high-tension lines, and insulation material for certain types of spark plugs. The latest development is a nonmetallic heating element for high temperatures, above the range of metallic elements. These are known as "hot rod" silicon carbide heating elements.

Low-Capacitance Power Supply for Direct-Coupled Circuits

A low-capacitance type of a-c operated power supply has been developed recently by J. H. Reaves of the National Bureau of Standards (NBS). The supply is designed for use in numerous direct-coupled circuit applications where conventional power supplies are unsuitable. The low-capacitance feature, which is achieved primarily by special design of the 60-cycle power transformer, enables the power supply to be employed in wide-band direct-coupled circuits requiring a power source with neither of its terminals grounded or by-passed to ground.

The establishment of proper d-c operating potentials for tubes is a frequent and troublesome problem in the design of direct-coupled circuits. One solution is to use a battery in series with the signal source. However, the replacement or maintenance required of a battery, especially in cases where it must supply appreciable power, is a serious disadvantage. A conventional a-c operated power supply cannot be substituted in this application because of its capacitive shunting effect on the signal.

In the NBS-developed power supply, the shunting capacitance to ground has been reduced to such a low value as to be negligible in the circuits for which the supply is designed. The capacitance reduction is accomplished by inserting an air gap between the core and the one or more secondary windings of the power transformer, and by compactly mounting the entire secondary circuit on an insulated chassis. Typical capacitance values obtained with this design range from 8- to 18 micromicrofarads and are comparable to the stray shunting capacitances of equivalent batteries. With moderately low driving impedance, this amount of capacitance has no appreciable effect at frequencies below several megacycles.

To reduce magnetic leakage resulting from the isolating air gap in the transformer, and thereby improve the voltage regulation, a split primary winding is usually employed, one-half on each side of the secondary winding. The voltage regulation is further improved in a 200-volt 20-milliampere model of the supply by use of electronic stabilization; in this model the output voltage varies approximately 1 per cent from no load to full load, and over a reasonable range of line voltages.

An added advantage of the NBS low-capacitance power supply over batteries is that the output voltage of the former can be varied easily and continuously. This is accomplished conventionally, either by an internal potentiometer in the case of the electronically regulated model or, with the other models, by an external variable-voltage transformer.

The special power supply is particularly useful in the laboratory as a means for easily determining the proper operating voltages for experimental circuits. In addition to the direct-coupling application, for which it is uniquely suited, it may also be used in circuits in which one terminal is grounded, though it offers no advantages when used in such conventional applications.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Decilog

To the Editor:

It was heartening to read the letter regarding the decilog in the January, 1955, issue, by Mr. E. Oosterling. His logic, in discussing the question of a suitable and sound abbreviation, should be studied and be heeded by American engineers.

Extension of the logarithmic unit idea to meters, grams, gauss, etc. seems, however, to raise further questions of a basic and a practical nature.

An expression such as 4 loggauss would appear to be fundamentally imprecise, because the logarithmic base is not indicated, and is also at least as cumbersome to use as is the accepted terminology 4×10^4 gauss. The latter is precise, is accepted by long usage, and is not unduly cumbersome.

Logarithms, and logarithmic units such as the bel and the neper, have a basic purpose. That purpose is to be able to obtain the results of multiplication or division by the simpler processes of addition or subtraction. In the case of electrical communication systems, there is the practical advantage that such a unit not only expresses a mathematical ratio, but also affords a unit of gain or loss. Addition or deletion of a few miles of cable, or of an amplifier, or a resistance "pad," etc., requires merely the addition or subtraction of the decibel gains or losses, of the individual circuit elements, to determine the over-all performance.

The logarithmic unit thus has a very definite place in certain types of engineering work, where it is necessary to think primarily in terms of ratios rather than of arithmetical increments. However, where the thinking necessarily must be in terms of absolute values or of arithmetical increments, it would appear that the use of logarithmic units should be avoided.

Mathematical terminology, for general engineering use, should clarify rather than confuse.

JOHN B. MOORE

(RCA Communications, Inc.)

Engineering Registration

To the Editor:

I am very grateful for the article "Engineering Registration," by A. G. Stanford, appearing in *Electrical Engineering* November, 1954, p. 961–62. I hope it will instill in many the desire to obtain registration in spite of its "apparent" uselessness. While the author has covered three very good points, I feel that he has overlooked one point which would overshadow the other three. I am referring to industry's attitude toward its own engineers. To the engineer working in industry, the only incentive for registration is the self-satisfaction of fulfilling the necessary requirements. Does the employer, who is probably an engineer himself, not realize that by fulfilling the requirements for registration the employee is a better man—a man who has refreshed his mind in engineering principles, and a man who has a new appreciation of the responsibilities of being an engineer? Should not, then, the employer, for it is the employer who has gained a better man, reward the employee for his efforts?

I think that a great deal could be accomplished toward this end if the employer were to reward a young engineer for registering, not only by a token pay increase at the time of registration, but also by encouraging registration, by treating engineers as professional employees, and by supporting the national society. It would not be unreasonable to expect the employer at least to partially compensate the engineer for the expenses incurred.

To the best of my knowledge I have never seen anything written on the contribution that can be made by the employer toward a greater engineering profession. That is probably because most of the articles are written by employers, most of whom did not have to pass an examination, and therefore do not fully appreciate the position of the young engineer about whom they are writing

I hope that my comments will be of value in promoting the profession in which I am proud to serve.

FRED A. HATFIELD

(Line Material Company, Zanesville, Ohio)

Leakage Reactance of Windings

To the Editor:

In connection with my paper on "Leakage Reactance of Irregular Distributions of Transformer Windings," which appeared in AIEE *Transactions*, vol. 73, pt. III, October, 1954, pp. 1078–86, Dr. E. Billig of Aldermaston, England, has written to me calling

attention to his (British) Institution of Electrical Engineers (IEE) paper entitled "The Calculation of the Magnetic Field of Rectangular Conductors in a Closed Slot, and Its Applications to the Reactance of Transformer Windings," to be found in the IEE *Proceedings*, vol. 98, pt. IV, 1951. This paper contains a few additional bibliographic items also, and those who are interested in this field may wish to make a note of it in their files.

ARAM BOYAJIAN (AM '18, F'26)

(Professional Consulting Engineer and Registered Patent Agent)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ASTM STANDARDS ON METALLIC ELECTRICAL CONDUCTORS. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1954. 270 pages, 9 by 6 inches, paper. $3.25. A compilation of all the standards pertaining to metallic conductors for use in insulated or uninsulated, covered or uncovered form. They include wire, standard conductors, rods, bars and shapes, and pipes and tubes of copper, copper alloy, and copper-covered steel; aluminum wire and other aluminum conductors; and various types of galvanized iron and steel conductors. Among the new standards added to this edition is a test method relating to copper wire for magnet-wire fabrication and specifications for copper used in hookup wire for electronic equipment.

AMERICA'S RESOURCES OF SPECIALIZED TALENT. The Report of the Commission of Human Resources and Advanced Training. Prepared by Dael Wolfle, director. Harper Brothers, 49 East 33rd Street, New York 16, N. Y., 1954. 332 pages, 8¼ by 5¼ inches, bound. $4.00. Presents results of a study of the characteristics of extensively and formally educated specialists, such as those in economics, agriculture, management, physics, and engineering. Three main problems considered are supply and occupational distribution, present and future demands, and the potential supply. A chapter of suggestions for improving utilization of the portion of the population able to benefit by further training is included.

CONTRIBUTIONS TO THE SOLUTION OF SYSTEMS OF LINEAR EQUATIONS AND THE DETERMINATION OF EIGENVALUES. (Applied Mathematics Series, no. 39) Edited by Olga Taussky. National Bureau of Standards (available from Superintendent of Documents, G.P.O., Washington 25, D. C.) 1954. 139 pages, 10½ by 8 inches, bound. $2.00. Contains seven papers dealing mainly with various aspects of the solution of simultaneous equations, including practical methods with worked examples, a study of iterative procedures, manual computation methods, experiments with punched cards equipment, and high-speed computations. Two of the papers deal with the rank of a matrix and location of its eigenvalues.

DETERIORATION OF MATERIALS. Causes and Preventive Techniques. Edited by Glenn A. Greathouse and Carl J. Wessel. Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N. Y., 1954. 835 pages, 9¼ by 6¼ inches, bound. $12.00. Basic principles involved in the preservation of materials are discussed and the most effective practical preventive measures are summarized. The first section covers causes of deterioration and the nature of deterioration processes. The next two sections discuss prevention for broad classes of specific materials: metals, wood, paper, textiles, plastics, paints, etc; and for assembled units: electric, electronic, and photographic equipment, and optical instruments. References are cited after each chapter.

ELECTRIC SYSTEM OPERATION. Edited by Bernhardt G. A. Skrotzki. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1954. 370 pages, 9¼ by 6¼ inches, bound. $6.50. This is the last of a series of four volumes written by professional engineers for readers without an engineering background who want to gain understanding of the utility system as a whole. It is devoted to some of the major problems of operating equipment for generating, transmitting, and distributing electric power. Chapters on operating costs and rate schedules are included.

ELECTRIC TRANSMISSION AND DISTRIBUTION. Edited by Bernhardt G. A. Skrotzki. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., first edition, 1954. 448 pages, 9¼ by 6¼ inches, bound. $7.50. A book for electrical mechanics and technicians, with mathematics limited to simple arithmetic and elementary trigonometry. Electrical theory is reviewed in simplified form as a foundation for the major part of the book—description of the layout and function of equipment used in transmission and distribution systems. The general picture of the utility industry given may be of interest to the engineering student entering the field.

ELECTRICAL ELEMENTS OF POWER TRANSMISSION LINES. By Herbert Bristol Dwight. Macmillan Company, 60 Fifth Avenue, New York, N. Y., 1954. 188 pages, 9½ by 6¼ inches, bound. $4.25. This is an up-to-date treatment of the subject, including load studies, symmetrical components for short circuits, cost of resistance loss, temperature rise of conductors, and calculation of reactance by use of geometric mean distance. The book is intended for college students with only an elementary knowledge of trigonometry and calculus, and includes a number of problems, with answers given at the end of the book.

HANDBOOK OF MICROWAVE MEASUREMENTS. Edited by Moe Wind and Harold Rapaport. Polytechnic Institute of Brooklyn; Microwave Research Institute, 85 Livingston Street, Brooklyn, N. Y., 1954. Two volumes, 11½ by 8½ inches, bound. $12.00/2 vol. This handbook, prepared for the use of engineers and technicians, is divided into 20 sections, each devoted to a characteristic quantity: standing wave ratio, attenuation, dielectric constant, magnetron characteristics, and others. Each section gives detailed information on methods and techniques, frequently accompanied by examples and by a substantial amount of associated theory, discussion of accuracies, and other pertinent information. All illustrations are assembled in the second volume to enable simultaneous consultation with the text in the first.

INVENTIONS AND THEIR PROTECTION. By George V. Woodling. Matthew Bender & Company, Inc., 109 State Street, Albany, N. Y., second edition, 1954. 495 pages, 9¼ by 5¼ inches, bound. $10.00. This book is intended as an aid to executive engineers and designers in the protection and commercial development of inventions. Nontechnical language is used in discussing patent ownership, filing applications, drafting claims, selecting and registering trade marks, and related subjects. This revision includes additional problems, new legal citations, and changes made to bring the text into conformity with the Patent Codification Act of 1953.

NEW INSTRUMENTAL METHODS IN ELECTROCHEMISTRY. Theory, Instrumentation, and Applications to Analytical and Physical Chemistry. By Paul Delahay. Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, N. Y., 1954. 437 pages, 9¼ by 6¼ inches, bound. $11.50. A comprehensive critical review of new experimental modes of approach, theoretical advances, and applications. The first part covers fundamentals (including a simple treatment of electrochemical kinetics) and various methods involving current and voltage measurements: voltammetry, voltammetric titrations and others. Part two deals with coulometry, electrolysis at controlled potential, and related methods. The remaining two parts cover high-frequency methods (by C. N. Reilley), and instrumentation.

OPTICS. (Lectures on Theoretical Physics, volume IV) By Arnold Sommerfeld. Translated by Otto Laporte and Peter A. Moldauer. Academic Press Inc., 125 East 23d Street, New York 10, N. Y., 1954. 383 pages, 9½ by 6 inches, bound. $6.80. This volume is closely connected with Volume III of the lectures (Electrodynamics), and assumes a knowledge of Maxwell's equations. The main topics discussed are reflection and refraction, optics of moving media, the theory of dispersion, crystal optics, and diffraction. A final chapter of addenda, chiefly devoted to additional diffraction problems, also considers the Cerenkov electron, geometrical optics, and the nature of white light.

TABLES OF INTEGRAL TRANSFORMS, VOLUME II. Compiled by the Staff of the Bateman Manuscript Project. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1954. 451 pages, 9¼ by 6¼ inches, bound. $8.00. Somewhat more than half of this second, and last, volume contains tables of further integral transforms—Hankel transforms and other integral transforms whose kernel is a Bessel function, fractional integrals, Stieltjes, and Hilbert transforms. The remainder of the volume contains integrals of higher transcendental functions. All notations are explained in an appendix.

TEXTBOOK OF SERVOMECHANISMS. By John C. West. English Universities Press Ltd., London (available in U.S. from Macmillan Company, 60 Fifth Avenue, New York 11, N. Y.) 1953. 238 pages, 8½ by 5¾ inches, bound. $5.00. This is an introduction to the subject for undergraduates and for engineers who are not specialists in the field. A simple system is described and used, with modifications and additions, to develop the theory and behavior of control systems and their characteristics. Important books for further study are listed at the end of the text.

TIME-SAVER STANDARDS. An Architectural Record Book. F. W. Dodge Corporation, 119 West 40th Street, New York, N. Y., third edition, 1954. 888 pages, 11¼ by 8¾ inches, bound. $12.50. Essential information for architectural drafting, designing, and specification writing is presented in this manual in condensed, graphic style. The six sections provide readily usable information on office practice, structural design, residential and nonresidential design elements, site planning, landscaping, and building materials and equipment. Some of the material in the previous edition has been eliminated and more than 100 pages have been added.

DER ULTRASCHALL. Und seine Anwendung in Wissenschaft und Technik. 6th Edition By Ludwig Bergmann. S. Mirzel Verlag, Zürich, Switzerland, 1954. 1114 pages, 9 by 6 inches, bound. Sw. Fr. 72.00. This monograph is a comprehensive review of the current state of ultrasonics research. A new chapter on the physics of sound has been added at the beginning of the present edition and many chapters have been revised or rewritten to incorporate new material. The bibliography now consists of over 5,000 references.

WEATHER MODIFICATION: PAST, PRESENT AND FUTURE. By Kenneth M. Arenberg and others, students at the Harvard Business School. Waymouth Gazette Press, Inc., Weymouth, Mass. Available from Weather Modification Group, 270 Beach Street, Wollaston, Mass., 1954. 50 pages, 11 by 8½ inches, paper. $5.00. This brief report on technical developments and potential uses of cloud seeding activities, covers the history of rainmaking, cloud physics, measuring results of seeding, and present commercial and government projects. There are also chapters on legal and regulatory issues, and on possible applications in agriculture, industry, hydroelectric power plants, municipalities, etc. Bibliography is included.

WELDING FOR ENGINEERS. By Harry Udin, Edward R. Funk and John Wulff. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 430 pages, 8½ by 5¼ inches, bound. $7.50. This textbook, based on a course given to juniors at the Massachusetts Institute of Technology, emphasizes principles and adopts, wherever possible, the analytical rather than the empirical approach. All the important unit processes are covered, with the amount of material devoted to a given process dependent on its industrial importance.

DIELECTRIC MATERIALS AND APPLICATIONS. Edited by Arthur R. von Hippel. Technology Press of Massachusetts Institute of Technology and John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 438 pages, 11¼ by 8½ inches, bound. $17. These papers, contributed by experts from science and industry, deal with the macroscopic and molecular properties of dielectrics, measuring techniques, materials and their applications, and requirements of the armed services. Materials considered are gases, liquids, plastics, and ceramics. Applications discussed include power and distribution equipment, electronic equipment, capacitors, and cables. The book includes volume four of the Tables of Dielectric Materials issued by the Laboratory for Insulation Research of the Massachusetts Institute of Technology.

INSTALL WIREWAYS FASTER!

SQUARE D's NEW AND EXCLUSIVE *Lay-in Duct*

FASTER ASSEMBLY!
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UNIVERSAL TYPE HANGERS

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KNOCKOUTS MATCH THOSE ON RELATED SQUARE D EQUIPMENT. NO CONDUIT BENDING

Square D's exclusive design provides hinged covers for both the duct sections and connectors. Easily removable fitting covers then provide a completely unobstructed wireway in which to lay wires.

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- Single phase motors.
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- Gasoline engine speed control.
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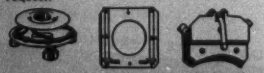
Accurately produced to your specifications, Syncro-Snap switches feature absolutely uniform operating characteristics . . . cut-out/cut-in speeds are held to any desired tolerance . . . non-fluttering, instant switching action is completed within 3 revolutions . . . action is determined by speed alone independently of voltage or load . . . unit employs only one moving part . . . and Syncro-Snap switches withstand millions of operations in actual use. Send your requirements or problems today! Standard samples available on letterhead request.



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INDUSTRIAL NOTES ....

Welding Data on Records. "Eutectic Welding Institute on Records," a 2-hour 33-rpm album of the week-long courses held at Eutectic Welding Alloys Corporation, Flushing, N. Y., is now available. The material on the records is the same as given the company's district engineers during training. The records are accompanied by a 60-page manual with "blackboard" diagrams, a reference copy of the records script, a series of eight tests with answers, and an indicator showing subjects covered on various parts of the records. Welding procedures, low heat input of various metals, and an introduction to metallurgy are included. The records are free on a loan basis when available from Eutectic district engineers.

Allen-Bradley Personnel Changes. The Allen-Bradley Company, Milwaukee, Wis., announces the appointments of new district managers. Walter F. Hammer, formerly sales engineer for the Cincinnati, Ohio, office, will be in charge of the Dayton, Ohio, office, and Charles H. Hawks, formerly in charge of the Flint, Mich., branch, has been appointed manager of the Pittsburgh, Pa., office. The Flint branch will be managed by T. C. Herbes, former sales engineer working out of Detroit, Mich., while the former Pittsburgh manager, Harry Thornberry, will open a new sales engineering office for the company in Bridgeport, Conn.

New Allen-Bradley sales engineers are Robert L. Gove in the Detroit office and Harold Mittelman at Cincinnati. J. F. Hoheisel, sales engineer in charge of the Dayton office, has been transferred to Cleveland, Ohio, as application engineer.

Hevi Duty Names Mauerer. Leo Mauerer has been named to the position of engineering consultant with the Transformer Division of Hevi Duty Electric Company, Milwaukee, Wis. He was formerly with Jefferson Electric Company and and has had some 27 years of transformer design and application experience.

Ilsco Appoints Representative. The Ilsco Corporation, Cincinnati, Ohio, announces the appointment of Frank P. Deveny, Minneapolis, Minn., as representative in Minnesota, North Dakota, South Dakota, Nebraska, and parts of Iowa and Wisconsin.

New American Brass Plant. The American Brass Company, wholly owned subsidiary of Anaconda Copper Mining Company, will construct an integrated aluminum mill on the outskirts of Terre Haute, Ind., according to a recent announcement. The new mill, together with a separate office building, will cover 500,000 feet and will be of 1-story heavy-steel construction with overhead crane service throughout. Production at Terre Haute will include casting of aluminum ingots and billets, rolling of sheet and strip, and extrusion of tubes, rods, and special shapes. James F. Ackerman, currently serving as vice-president of the company's Torrington, Conn., plant, will be in charge of the new fabricating operation.

Manager for U. S. Testing. Lawrence J. Perenic has been named manager of the electronics department of the United States Testing Company, Hoboken, N. J. Mr. Perenic previously had been with the Bogard Manufacturing Corporation, Brooklyn, N. Y., and had been on the staff of the Western Electric Company, New York, N. Y. He is a graduate of Brooklyn Polytechnic Institute.

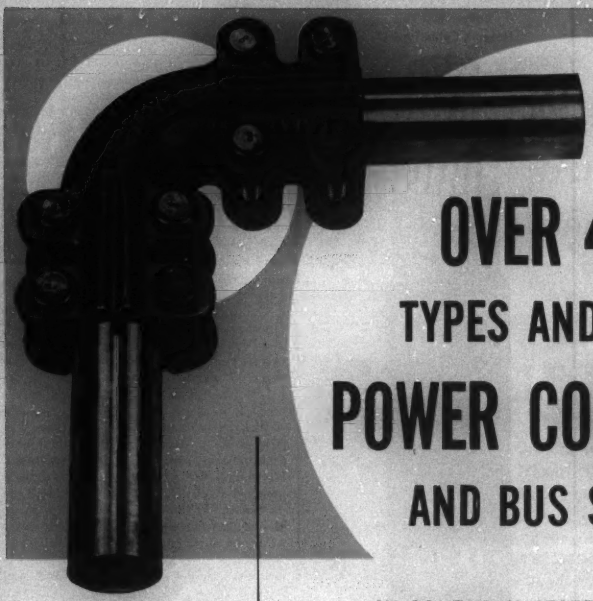
New Micro Switch Offices. Establishment of new sales and engineering offices in Phoenix, Ariz.; Charlotte, N. C.; and Denver, Colo., has been announced by Micro Switch, a division of Minneapolis-Honeywell Regulator Company. Ralph C. Froehlich, formerly of Los Angeles, Calif., heads the new Phoenix office; Donald S. Schultz is being transferred from Philadelphia, Pa., to take charge of the Charlotte office; and Ralph J. Petersen, formerly of Minneapolis, Minn., is in charge in Denver.

Sperry Appointments. Appointment of several men to executive positions in the new Aeronautical Equipment Division of Sperry Gyroscope Company, Great Neck, N. Y., has been announced by H. C. Bostwick, division manager. Sales manager of the new division is Frank Conace, former director of field service engineering. Spencer Kellogg, formerly department head of flight instrument engineering, will assume the responsibilities of engineering manager. Manufacturing duties will be handled by Michael Curatolo as manufacturing superintendent, Thomas Hannah as manufacturing planning superintendent, and Anthony Ruggiero as quality control superintendent.

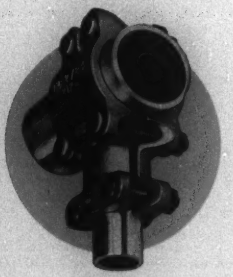
Du Mont Organization Changes. Major organization changes by Allen B. Du Mont Laboratories, Inc., Clifton, N. J., have resulted in the election of William H. Kelley as vice-president and general manager of all manufacturing and sales divisions, and the appointment of William C. Scales as manager of the Receiver Sales Division. Mr. Kelley had been vice-president, marketing. Mr. Scales formerly was sales manager of Du Mont's Cathode-Ray Tube Division.

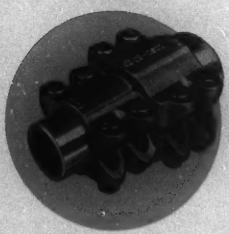
General Electric News. Three appointments in the General Electric Company's plastics department management, Pittsfield, Mass., have been announced. G. Stanley Berge was named manager—marketing; K. O. William Sandberg was appointed manager—engineering; and Arthur T. Bourgault became manager of the department's Taunton, Mass., custom

(*Continued on page 22A*)



OVER 4,000
TYPES AND SIZES OF
POWER CONNECTORS
AND BUS SUPPORTS





IN SOUTHERN STATES' COMPLETE LINE

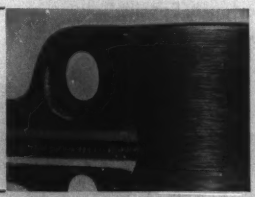
To meet the widest range of requirements for power and grounding connectors, Southern States produces more than 4,000 different types and sizes—many on special order to customers' specifications.

Widespread use of self-supporting, rigid, tubular bus constructions in substations has increased the mechanical requirements of many connectors. That is why Southern States connectors have been re-designed during the past two years. They now have stronger ears and are 40 to 50% heavier.

When you specify and use Southern States connectors, you can be sure they are capable of: 1) serving as self-supporting members; 2) providing good electrical connection; 3) developing full strength of clamping bolts without visible distortion; 4) carrying current equal to the conductor without excessive temperature rise; 5) being installed with a minimum of effort and time.

Rough Ground for Best Possible Contact

Every Southern States connector is rough ground on all contact surfaces. This permits the connector to bite into the conductor, causing intimate metal to metal engagement at thousands of high-pressure contact points, thus providing a better junction and one that is sealed against corroding atmosphere.



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Collyer 600 Volt
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FOR STABILITY

See how Collyer Standard Network Cable Insulation retains ASTM D-754 requirements:

After 12 months in water at 50°C, Collyer insulation tested
780 psi Tensile Strength
500% Elongation

ASTM D–754 requirements on unaged insulation
700 psi Tensile Strength
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You will find top performance like this engineered into every Collyer Cable: we consider stability of great importance. Specify Collyer the next time you need cable.

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COLLYER INSULATED WIRE CO.
245 ROOSEVELT AVE.
PAWTUCKET, R. I.

(*Continued from page 18A*)

molding plant. Mr. Berge had been manager of the custom molding plant, Mr. Sandberg had been manager—operations research in the plastics department, and Mr. Bourgault formerly was manager of the Alkyd resin products plant in Schenectady, N. Y.

Robert G. Page has been named manufacturing engineering specialist for the distribution assemblies department of General Electric in Plainville, Conn., while George B. Bowers has been appointed employee and plant community relations specialist. Mr. Page has been with General Electric since 1948, and Mr. Bowers joined the company in 1953.

Complete reorganization of the Lamp Division at Nela Park, Cleveland, Ohio, has been announced. The reorganization involves decentralization of the division by the creation of six product or business departments and an advanced lamp development laboratory, in addition to the two service departments now in existence. The new products departments and their general managers are: large lamp department, Herman L. Weiss; miniature lamp department, Kenneth G. Reider; photo lamp department, William E. Davidson; lamp glass department, Ernest A. Howard; lamp wire and phosphor department, Robert F. Johnson; lamp leads and bases department, Walter P. Cartun. Carl L. Olson will be manager of the laboratory. The two service organizations are the legal department with Douglas S. Moore as counsel and the lamp equipment operation with William R. Gerow as manager.

IBM Promotions. The International Business Machines Corporation recently announced the appointment of Dr. Cuthbert C. Hurd as director of electronic data-processing machines (EDPM). Director of IBM's applied science division since it was established in 1949, in his new post Dr. Hurd will co-ordinate all of the company's engineering, manufacturing, and product planning activities in the electronic data-processing field. The company also announced the appointment of Thomas E. Clemmons, formerly district manager with headquarters in Atlanta, Ga., as sales manager of the EDPM Division.

IRC Appoints Assistant Director. The International Resistance Company, Philadelphia, Pa., has named Timothy P. Haworth, the company's training director for the past 4 years, as assistant director of industrial relations. He will assist in the administration and co-ordination of all industrial relations activities of company plants in Philadelphia and Downington, Pa., and Asheville and Boone, N. C.

Battery Plant Engineers. Four appointments of plant engineering personnel have been announced by The Electric Storage Battery Company, Philadelphia, Pa. Wilbur W. Ferris, plant engineering manager of the firm's Crescentville plant in northeast Philadelphia since 1952, has been transferred to Cleveland, Ohio, as manager of

(*Continued on page 30A*)

Nautilus

first
atomic submarine
uses

TIGER BRAND ELECTRICAL CABLE

The Nautilus was built by General Dynamic Corporation's Electric Boat Division shipyard, at Groton, Conn. She was launched on January 21, 1954.

Very frankly, we cannot recall a more *critical* application of electrical cable than this new atomic-powered submarine. And from one end to the other, this amazing boat is laced with Tiger Brand Electrical Cable.

But here's the important thing—*you* can get the same quality that went into the Nautilus. Just call your American Steel & Wire salesman.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL
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COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
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A STANDARD TIGER BRAND CABLE FOR EVERY SPECIAL JOB!

paper & varnished cambric cable
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HAND YOUR SPECIAL TRANSFORMER PROBLEMS TO...

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TRADE MARK

YOU CAN SAVE many valuable man-hours and production hours by placing your special transformer problems in the capable hands of experienced STANDARD TRANSFORMER engineers. STANDARD engineers can easily detail all of your transformer requirements and oversee their manufacture from beginning to end. There's a STANDARD representative near you. Call him today!

300 KVA indoor unit sub-station or load center, consisting of high voltage, fused air brake switch and low voltage section with circuit breakers and transformer

THE Standard TRANSFORMER CO.
WARREN, OHIO
REPRESENTATIVES IN PRINCIPAL CITIES

(*Continued from page 22A*)

equipment and plant engineering, Automotive Division. Earl R. Miller has been appointed to succeed Mr. Ferris at Crescentville. A. H. Shaw, previously with the Exide Automotive Division, Fairfield, Conn., has been named plant development engineer. Robert L. Chalfant, who joined Exide in 1951, has been appointed a plant engineer.

Moloney Names Perkins, Knox. Chester W. Perkins has been made vice-president in charge of application engineering by the Moloney Electric Company, St. Louis, Mo. He joined the organization in 1947 as an electrical engineer, and was instrumental in organizing company headquarters for field engineering and a service group to handle field engineering problems. John J. Knox, vice-president of the company, has been named assistant sales manager. He has been with Moloney for the past 25 years.

Wolverine Tube Announcement. The appointment of R. C. Crowe to the sales staff and the transfers of K. F. Egan and E. J. Finn were announced recently by Wolverine Tube, Division of Calumet and Hecla, Inc., Detroit, Mich. Mr. Crowe will take over Mr. Finn's former territory in southeastern Michigan. Mr. Finn will transfer to Mr. Egan's former territory, Boston, Mass., and environs; and Mr. Egan will relocate in Rochester, N. Y., serving upper New York state.

SRI Appoints J. D. Noe. Stanford Research Institute, Stanford, Calif., has announced the appointment of Dr. Jerre D. Noe as assistant director of engineering research. Joining Stanford Research in 1948, Dr. Noe was one of the first members of the engineering division. Also appointed were Dr. Byron J. Bennett as manager, computer laboratory, and Dr. Kenneth R. Eldredge, manager, control systems laboratory. Dr. Bennett, with SRI since 1952, was formerly an associate professor at Texas Technological College, Lubbock. Dr. Eldredge joined SRI in 1953, after 6 years with the Office of Naval Research, London, England, branch.

NEW PRODUCTS . . .

Antenna Towers. The Engineering Products Division, Radio Corporation of America, has announced availability of a line of RCA television antenna towers, for use by all types and sizes of vhf and uhf stations. The steel, lattice-type towers will be available in seven different basic designs and will be fabricated to the height requirements of the individual broadcaster. The availability of antenna towers in a variety of standard designs can be expected to streamline fabrication costs and speed delivery.

(*Continued on page 36A*)

MILLIONS OF FEET NOW IN SERVICE

BECAUSE OF PROVED PERFORMANCE

ROCKBESTOS

PNR SMALL DIAMETER CONTROL CABLE

There are still a few who haven't yet taken advantage of PNR . . . the lighter, smaller control cable. But it's come a long way since we first introduced its Polyethylene, Nylon, Rockhide insulation to industry just six short years ago.

Today, many utilities specify it. And there's a million feet in service.

If you haven't tried it yet, get the complete PNR story today. Write or ask your nearest Rockbestos representative.

*Average determined by comparison with conventional control cable.

PROPERTIES OF PNR

46% smaller in area* . . . 28% smaller in diameter* than conventional control cable.
Use smaller conduit and fittings or put more conductors in existing conduit.
Lighter, easier to handle, store, ship, pull through conduit.
Dielectric breakdown . . . over 40 times operating voltage.
Rated 600 volts . . . conductor operating temperature 167°F.
Flexible from 167° to —67°F.
No cracking!

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NEW HAVEN 4, CONN.

NEW YORK • CLEVELAND • DETROIT
CHICAGO • PITTSBURGH • ST. LOUIS
LOS ANGELES • NEW ORLEANS
OAKLAND, CALIFORNIA • SEATTLE

. . . for any operating temperature up to 392°F or 200°C, there is a Stock

CONTINENTAL APPARATUS CABLE, BOILER ROOM WIRE, HEADLIGHT WIRE, MINING CABLE, MOTOR LEAD CABLE, POWER CABLE, SWITCHBOARD WIRE OR CABLE.

Serving 600 to 5,000 volts, in sizes 18 AWG to 2,000,000 CM:
HEAT- & MOISTURE-RESISTANT WIRES, CABLES & CORDS for

Air Conditioners, Airplanes, Bakeries, Bake Ovens, Ballast Transformers, Boiler Rooms, Busses, Control Stations, Clothes Dryers, Commercial Refrigerators, Cranes, Dry Kilns, Electric Furnaces, Electric Motors, Electric Ranges, Electronic Equipment, Hair Dryers, Heat Controls, Heating Elements, Infra-red Heat, Lighting Fixtures, Locomotives, Mercury Switches, Motion Picture Machines, Oil Burners, Panel Boards, Paper Mills, Power Houses, Pyrometers, Radios, Range Lights, Range Timers, Resistance Soldering, Restaurant Equipment, Rheostats, Sewing Machines, Show Case Lights, Smokehouses, Soldering Irons, Spotlights, Stage Lights, Steel Mills, Switchboards, Table Stoves, Television Sets, Thermostats, Toasters, Waffle Irons, Water Heaters

Type for type, CONTINENTAL Wires and Cables supply among the *highest rated temperatures, highest current capacities, widest range of sizes* available. Write for stock-catalog, or about your particular requirements — special wires manufactured to meet specific conditions.

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(*Continued from page 30A*)

Indicating Millivoltmeter. An indicating millivoltmeter which features minimum response time less than 6 seconds for 99-per-cent response and accuracy of 1 per cent of full scale value has been announced by The Bristol Company, Waterbury, Conn. The instrument has a newly developed high-torque jeweled millivoltmeter mechanism, with an Alnico V magnet and a self-supporting coil. It can be used as a pyrometer, tachometer, or pH indicator, or for power consumption measurements. Complete details on the indicator, Model *580*, are available from the company in Bulletin *P 1244*.

Control Hood. "Control Hoods" have been developed by P. M. Lennard and Company, Inc., Brooklyn, N. Y., to provide industry and research with a portable environmental housing designed to maintain controlled atmospheres of sterile or dust-free air, and varying relative humidities. The standard hood is cast of a single piece of shock-resistant optically transparent plastic. Where conditions require, standard hoods are available molded of an opaque, chemical- and heat-resistant fiberglass plastic. All hoods are supplied with a transparent front panel. Facilities are available to permit hands or objects to be inserted and removed from the hoods without the loss of the internal atmospheric conditions.

Wire Insulation. Synthesis of a new thin-film heat-resistant wire insulation for electric motors has been announced by the General Electric Company, Schenectady, N. Y. With the new insulation, known as Alkanex, the limiting temperature for long life has been raised to at least 300 F. The insulation, which can be applied by standard enameling equipment, possesses excellent abrasion and solvent resistance and resists flow at high temperatures.

A-C Panel Voltmeter. Alternating-current readings accurate to 0.5 per cent over the frequency range of 50 to 2,000 cps are obtained with the Expanded Scale Panel Voltmeter manufactured by Arga Division of Beckman Instruments, Inc., South Pasadena, Calif. Use of a thermal bridge permits the indication of a narrow voltage range. The scale is expanded about a given normal voltage which may be as low as 6.25 volts with a span of ± 0.25 volt, or as high as 230 volts with a span of ± 30 volts.

Drop Cable. A new type of service drop cable designed to withstand the abrasive wear and cutting action of tree limbs has been developed by the Rome Cable Corporation. The new cable is known as TreePlex. To the already tough polyethylene insulation covering each power conductor, Rome has added a tight, thin (0.005 inch) sheath of nylon. This compound has been heat- and light-stabilized, for extra-long weather resistance. Tests show that nylon sheath has increased the wear resistance of the new cable by more than 50

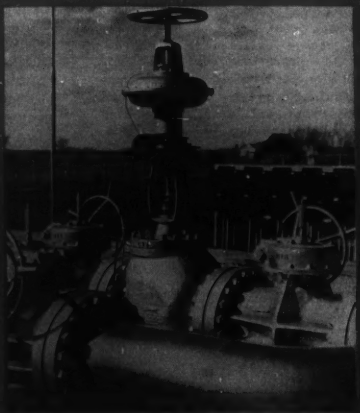
(*Continued on page 40A*)

.boosts Platte Pipe Line efficiency!

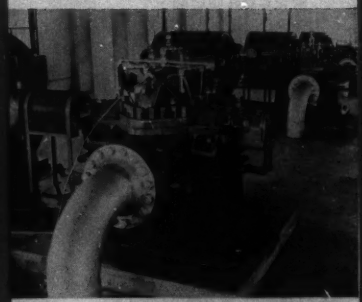
The Philco microwave system of the Platte Pipe Line Company—the largest and most comprehensive installation of its kind—demonstrates the economic advantages of microwave better than any other pipe line microwave system in the nation. Here is what A. R. Heidebrecht, Chief Engineer of Platte, has to say about the system: "Our decision to use microwave was greatly influenced by the number of pipe line control functions which could be accomplished remotely and automatically. Operation to date has proved very successful; in fact, during the short time this system has been in use, the efficiency of our pipe line operation has been substantially increased."

Perhaps microwave can lower operating costs and boost the efficiency of your plant. Philco maintains a staff of experienced field and system engineers who can help plan and install your microwave system. Get information on the many leading Philco microwave installations in use today. Write to Philco, Dept. EE.

Platte Pipe Line control center at Kansas City.



Microwave operates valves along the pipe line.



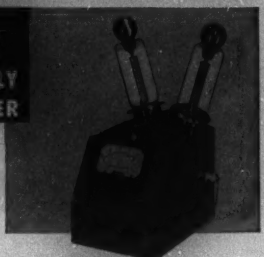
Pipe line pump station operated by microwave.

PHILCO—WORLD'S LEADING MANUFACTURER OF MICROWAVE

GOVERNMENT AND INDUSTRIAL DIVISION • PHILADELPHIA 44, PENNSYLVANIA

In Canada: Philco Corporation of Canada Limited, Don Mills, Ontario

VOLTAGES UP TO 100 KV
IN PULSE, RF, AND 60 CYCLE
CIRCUITS MAY BE READ DIRECTLY
ON JENNINGS J-1002 VOLTMETER



For the first time, vacuum capacitor voltage dividers have been integrated with a high impedance voltmeter to provide:

- Six linear voltage ranges including a 50 KV range for single-ended measurements and a 100 KV range for double-ended measurements. (These ratings may be doubled by using a Type JCD vacuum capacitor in series with each divider.)
- A frequency range of 20 cycles to 20 megacycles at full rated voltage and up to 50 megacycles for lower voltages with low harmonic content.
- Nearly infinite input resistance with a loading capacitance of less than 4 mmfd.
- Oscilloscope connections for each divider with voltage division ratios of 300:1.

Use it alone or with either divider connected directly to the vertical deflection plates of an oscilloscope. Use it to measure and view continuous 60 cycle, rf, and pulse voltages. Use it to calibrate oscilloscopes and to measure percentage of modulation, standing wave ratios, phasing, or unbalance. Use it to measure positive peaks, negative peaks, or peak-to-peak values of any symmetrical or non-symmetrical voltage wave.

SPECIFICATIONS

VOLTAGE RANGES (peak volts full scale):
Single Ended: 2.5, 5, 10, 25, 50 KV
Double Ended: 5, 10, 25, 50, 100 KV

FREQUENCY RESPONSE: 20 cps — 50 mc

INPUT IMPEDANCE:
Resistance: above 10^{12} ohms
Capacitance: less than 4 mmfds

CALIBRATION ACCURACY: ±3% of f. s.

POWER SUPPLY: 117 v., 50/60 c., 20 w.

DIMENSIONS: 16" x 10" x 10¾"

NET WEIGHT: 11 pounds

Jennings RADIO

SOLD DIRECTLY BY JENNINGS
$475.50 FOR SAN JOSE CALIFORNIA
including two 60 KV voltage dividers

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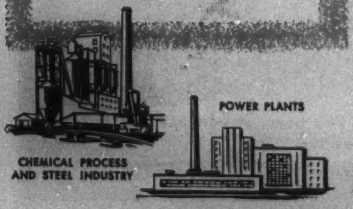
Industry looks to
RESEARCH -COTTRELL
for high dust collection efficiencies



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(*Continued from page 36A*)

times, as compared with standard Triplex service drop cable. Additional information about Rome TreePlex service drop cable can be obtained by writing to the Rome Cable Corporation, Rome, N. Y.

Improved Slotted Line. Operating over the frequency range from below 300- to 5,000 mc, the new General Radio type *874-LBA* slotted line is a convenient and accurate instrument for measurements of impedance, standing-wave ratio, and attenuation. Measurements on dielectric materials, lumped components, coaxial elements and networks, and antennas in the uhf range can be made simply, as well as accurately, with this slotted line and its associated components.

New Pressure Relief Device. An improved station-type arrester, type *SV*, containing a new safety pressure-relief device is now available from the Westinghouse Electric Corporation. The addition of exhaust ports on the arrester, makes possible the removal of the source of gas-generation, should the arrester lose its ability to limit or interrupt power-flow. The arc is transferred to the outside of the porcelain housing within one-half cycle, or less, of fault current. This prevents rupture of the porcelain housing by arc-generated gases. For further information write Westinghouse Electric Corporation, Box 2099, Pittsburgh, Pa.

Ionization Transducer. The Decker Aviation Corporation, 1361 North Frankford Avenue, Philadelphia 25, Pa., has announced a new type of transducer capable of incredible performance in hundreds of applications. Called the *T-42* ionization transducer, it offers extremely large output signals (as high as ±100 volts), better than average resolution, high sensitivity, static and dynamic response, a phase-sensitive d-c output signal, reproducible performance, good linearity if required, miniaturization, and an outstanding ease of adaptability to a tremendous variety of problems. Literature on the basic *T-42* ionization transducer, a pressure meter and a micrometer-comparator, both incorporating the *T-42*, is available upon request.

Mechanically Held Relays and Contactors. New mechanically held contactors and relays, especially designed for maintaining continuity of sequencing in the event of power interruptions, have been announced by the General Electric Company's general-purpose control department. Used also where exceptionally quiet operation is required, mechanically latched relays and contactors eliminate continued energization of the coil, thus eliminating coil hum. After the main device coil is momentarily energized to seal the contacts, the mechanical latch locks the contacts in position until the latch coil is energized. For this reason, when power is restored after a failure, sequenced operations will resume at the exact point in cycling where they were cut off. For further information on these prod-

(*Continued on page 44A*)

Fiberglas*-base varnished cloth now can be used for all classifications. Now priced competitively with organic materials, yet it resists heat and moisture far more effectively. Available from your distributor in both organic and inorganic finishes.

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FIBERGLAS

For Technical Data, Write: Owens-Corning Fiberglas Corporation, Electrical Division, 508 Madison Avenue, New York 22, N. Y.

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Precision Attenuation to 3000 mc!

TURRET ATTENUATOR featuring "PULL-TURN-PUSH" action

FREQUENCY RANGE:
dc to 3000 mc.
CHARACTERISTIC IMPEDANCE:
50 ohms
CONNECTORS:
Type "N" Coaxial female fittings each end
AVAILABLE ATTENUATION:
Any value from .1 db to 60 db
VSWR:
<1.2, dc to 3000 mc., for all values from 10 to 60 db
<1.5, dc to 3000 mc., for values from .1 to 9 db
ACCURACY:
±0.5 db
POWER RATING:
One watt sine wave power dissipation

Send for free bulletin entitled "Measurement of RF Attenuation"

•

Inquiries invited concerning pads or turrets with different connector styles

STODDART AIRCRAFT RADIO Co., Inc.

6644-B Santa Monica Blvd., Hollywood 38, California · Hollywood 4-9294

(*Continued from page 40A*)

ucts write for bulletin *GEC-1281* to General Electric Company, Schenectady 5, N. Y.

Versatile Ring Assembly. In answer to a growing demand for a standard "off the shelf" slip ring and brush assembly, the D. E. Makepeace Company, Division of the Union Plate and Wire Company, has announced an assembly which has been designed to meet a wide variety of applications for rotating electromechanical devices. From two to ten circuits can be obtained in one assembly, and two or more assemblies of ten can be stacked together to achieve a greater number of circuits. Currents up to 20 amperes and extremely low noise levels make these assemblies useful for a great variety of applications. Details as to shaft diameters, speeds, and other technical information can be obtained by writing D. E. Makepeace Company, Attleboro, Mass.

Bobbin Cores. Magnetics, Inc., is offering a complete line of performance-guaranteed bobbin cores, especially suitable for use as memory cells for electronic computers. These cores are wound on small ceramic bobbins with ultrathin magnetic tapes and have very rectangular hysteresis loops under pulse conditions. Because of this characteristic and ability of the small core to switch from positive to negative saturation in a very few microseconds, they can be used as memory cells. Complete details may be secured by writing Magnetics, Inc., Butler, Pa., for bulletin *BC-102*.

Insulated Terminal. A new compression-installed insulated terminal for high-temperature operation has recently been added to the Insulug connector line by Burndy Engineering Company. This new Insulug, called Thermolug, is designed for high ambient temperature operation in aircraft, or in any area of the aircraft where temperatures approach 400 F, such as fire alarm systems. The transparency of the insulation permits easy inspection of the installation, and longitudinal color striping promotes rapid size identification. For further information, write Burndy Engineering Company, Inc., Norwalk, Conn.

Ilsco Electric Lugs. Ilsco Corporation is now producing LO Solderless lugs in 125-, 225-, 300-, and 400-ampere sizes. Of special interest to users is the fact that the new design is produced from extremely hard tempered copper tubing which assures unusual strength. Heat tests show an average of about one-half the permitted temperature rise. Full details may be obtained by contacting Ilsco Corporation, Mariemont, Cincinnati 27, Ohio.

Hydraulic Pressure Switch. A newly designed, piston-operated hydraulic pressure switch has been announced by the Square D Company. The device may be used on hydraulic machine-tool applications where surges of considerable magnitude are present. A new strain relief mechanism has been incorporated in the switch which

(*Continued on page 50A*)

Fusetron Fuses Do More Than Eliminate Shutdowns Caused By Needless Blows . . .

FUSETRON FUSES PROVIDE 10 POINT PROTECTION . . .

1. Protect against short-circuits.
2. Protect against needless blows caused by harmless overloads.
3. Protect against needless blows caused by excessive heating—lesser resistance results in cooler operation.
4. Provide thermal protection — for panels and switches against damage from heating due to poor contact.
5. Protect motors against burnout from overloading.
6. Protect motors against burnout due to single phasing.
7. Give DOUBLE burnout protection to large motors — without extra cost.
8. Make protection of small motors simple and inexpensive.
9. Protect against waste of space and money — permit use of proper size switches and panels.
10. Protect coils, transformers and solenoids against burnouts.

FUSETRON FUSES SAVE YOU Maintenance and Recalibration Costs

Once properly installed, Fusetron fuses require no costly inspection time or maintenance necessary on mechanically operated devices.

Dust, fumes, corrosion or age cannot prevent a Fusetron fuse from opening safely. There are no hinges, pivots or contacts to stick or slow down the operation of the fuse on short-circuit.

When a Fusetron fuse does open to protect, and after the fault has been corrected — the new Fusetron fuse you have installed has been *calibrated at the factory by engineers* — it is a fuse as safe and dependable as the one that blew.

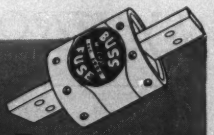
FUSETRON FUSES GIVE YOU GREATER SAFETY, BECAUSE OF THEIR HIGH INTERRUPTING CAPACITY

Tests verified by the Electrical Testing Laboratories of New York indicate that Fusetron fuses can interrupt safely the most severe available short-circuit current.

The tests circuits were set to deliver in excess of 100,000 amps. In each test the fuse cleared the circuit safely, the fuse remained intact, there was very little noise and cotton packed around the fuse was not ignited.

Yet there has been no interference with the time-lag characteristic of Fusetron fuses.

FOR LOADS ABOVE 600 AND UP TO 5,000 AMPS., BUSS Hi-Cap FUSES PROVIDE . . .



Unlimited interrupting capacity to handle any fault current regardless of system growth! This was confirmed by tests witnessed and reported upon by the Electrical Testing Laboratories of New York.

Overload protection as well as short-circuit protection.

Coordination with Fusetron fuses on feeder and branch circuits to limit fault outages to circuit of origin.

On old installations, a safe and relatively inexpensive way to protect inadequate circuit breakers against rupture in event of bad fault.

Dependable service through the years because there are no moving parts to stick or get out of order.

FUSETRON

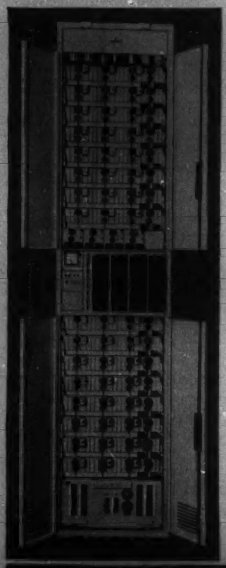
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION

BUSS

Blowing time charts and more information are available on FUSETRON Fuses and BUSS Hi-Cap fuses. Write for bulletin FIS and HCS.

BUSSMANN MFG. CO., (Division of McGraw Electric Company) University at Jefferson, St. Louis 7, Mo.

Fuses throughout the entire Electrical System!



SIXTY-CHANNEL CARRIER-TELEPHONE SYSTEM OF ADVANCED DESIGN FOR RADIO LINKS

The type F60 carrier-telephone system provides up to 60 channels, in 12-channel groups, on a four-wire basis for transmission over cable pairs or an FM radio system. Transmission is single-sideband suppressed-carrier in the frequency range 12 to 252 kc. Miniaturized plug-in equipment units are used, which also form part of universal carrier-telephone systems of from 3 to 960 channels. Channel band width is 300 to 3400 cycles. Three telephone channels in each group may be replaced by a 10-kc program channel. Built-in ringing and dialling facilities are available. The types FM 60/2000 Radio System, operating in the band 1700 to 2300 mc, FM60/300 Radio System, in the band 235 to 328 mc, and FM24/50 Radio System, in the band 41 to 68 mc, are designed for use with the F60 carrier-telephone system.

Forty-eight channel modems mount on one bay side. Two bays mount a complete type F60 terminal.

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MANUFACTURERS OF CARRIER-TELEGRAPH, CARRIER-TELEPHONE AND BROAD-BAND RADIO SYSTEMS

Investigate The Cost and Performance Advantages You Can Get with . . .

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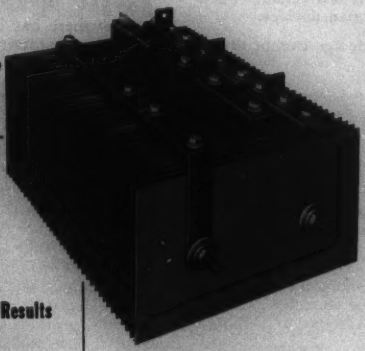

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- **Extremely Slow Ageing Results In Extended Life**
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- **Installations In Actual Operation Range Up To 600 KW**

SELENIUM RECTIFIERS

Approved salt spray and fungus resistant finishes available

Write today for complete performance and specification data—Free

SYNTRON COMPANY
440 Lexington Avenue Homer City, Penna.

(*Continued from page 44A*)

allows the range spring to absorb the impact of a violent pressure surge. An added feature is a Quad ring seal around the piston, preventing oil leakage and eliminating the necessity for an oil return line. Types without the Quad ring are available for closer differentials. These switches may be obtained with a range of 135 to 1,000 or 400 to 3,000 pounds per square inch. For further information, write the Square D Company, 4041 North Richards Street, Milwaukee 12, Wis., asking for class *9012* type *ADW* bulletin.

TRADE LITERATURE

Data Bulletins. Pacific Scientific Company, 1430 Grande Vista Avenue, Los Angeles, Calif., has announced the publication of 14 technical data bulletins on their rectilinear potentiometers; accelerometers; rate, free, and vertical gyroscopes. The new publications give application information, weight, size, performance data, and general specifications. Copies of these bulletins may be obtained by writing to the company.

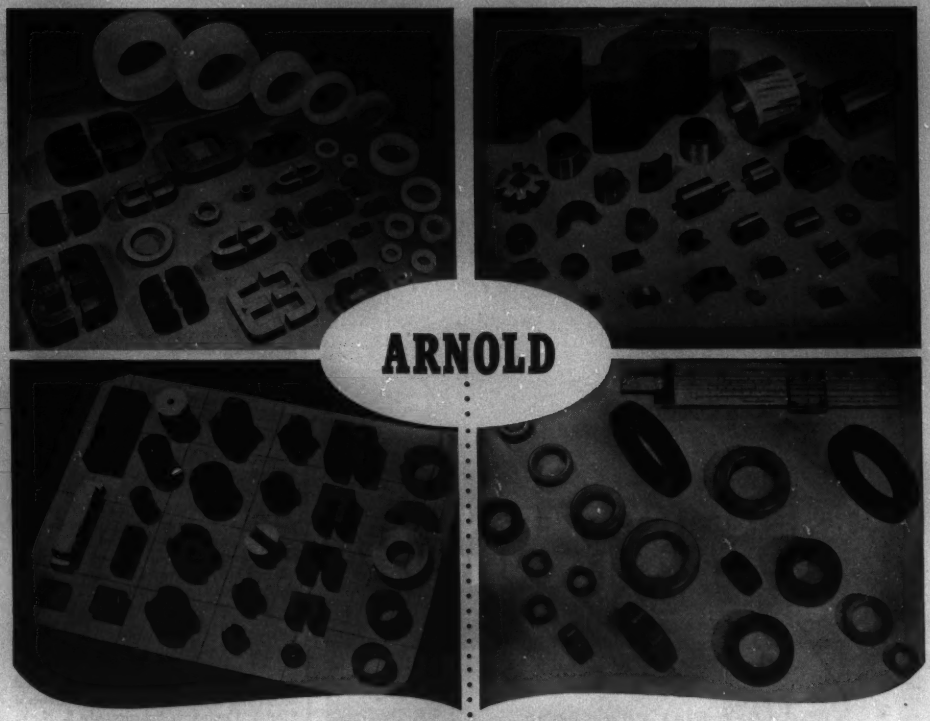
Cable Splicing Instructions. Simplex Wire and Cable Company, 79 Sidney Street, Cambridge 39, Mass., has released a new 8-page booklet which contains splicing instructions for relatively high-voltage cable. Form Number *990*, or the "High Voltage Splicing Instructions," is available, at no charge, from the manufacturer.

Motors Catalogue. A new condensed catalogue, *F 4271-5*, features a new line of high-power unidirectional small motors. Combining high starting torque with exceptional power output, the new Barcol *YAF* motors are described. Copies are available from Barber-Colman Company, Small Motors Division, 1200 Rock Street, Rockford, Ill.

Two Catalogues Offered. Freed Transformer Company, Inc., 1715 Weirfield Street, Brooklyn 27, N. Y., announces the availability of two new comprehensive catalogues covering Freed transformers. Catalogue number *545* is a 24-page bulletin containing complete descriptive material on Freed transformers, filters, magnet amplifiers, reactors, and toroidal inductors. Catalogue number *546* is a 16-page bulletin covering the company's complete line of laboratory test instruments. For copies of these catalogues write to the Freed Transformer Company.

Safety Catalogue. A new safety equipment catalogue has been prepared by the E. D. Bullard Company, manufacturers of industrial safety equipment. This catalogue is designed to give complete informa-

(*Continued on page 60A*)



YOUR ONLY SOURCE

of a Complete Line of MAGNETIC MATERIALS

Arnold products include all grades of Alnico permanent magnets (cast and sintered) . . . tape-wound cores of high-permeability alloys, such as Deltamax, Permalloy and Supermalloy . . . types "C" and "E" cut cores of Silectron in any size or weight range from a fraction of an ounce to hundreds of pounds (50 lbs. max. on 12-mil C cores); also round, square and rectangular Silectron cores . . . powdered Mo-Permalloy cores . . . Cunife, Vicalloy, Permendur and other magnetic materials. Special magnetic components can be produced to meet your specific requirements; and such products as powder cores, tape-wound cores, and C and E cores are carried in stock in a wide range of standard sizes for immediate delivery. Many sizes of cast and sintered Alnico magnets also are stocked.

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TECHNICAL DATA ON ARNOLD PRODUCTS . . . Write for your copy.

Bulletin GC-106 . . . General information on all Arnold magnetic materials: permanent magnets, tape-wound and powder cores, etc.

Bulletin TC-101 A . . . "Properties of Deltamax, 4-79 Mo-Permalloy and Supermalloy"—28 pages of technical data on Arnold Tape-Wound Cores.

Bulletin PC-104 . . . "Molybdenum Permalloy Powder Cores"—16 pages, complete technical data.

Bulletin SC-107 . . . "Arnold Silectron Cores"—52 pages of valuable data, covering a complete range of core shapes, sizes, tape gauges, etc.

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(*Continued from page 50A*)

tion on all of the company's products in a quick and efficient manner. Photographs of the items being explained are shown along with easy-to-read technical data. The Bullard Catalogue number *55* is available, free of charge, from the E. D. Bullard Company, 275 Eighth Street, Department 531, San Francisco 3, Calif.

Circuit Breaker Bulletin. Allis-Chalmers Company has released a new 8-page bulletin entitled "Allis-Chalmers Oil Circuit Breakers," number *71B7946A*, which contains design features, operator mechanism, ratings, dimensions, and weights of the company's power oil circuit breakers—types *OZ-15-100*, *OA-15-250*, and *OZ-23-250*. The circuit breakers are rated at 14.4 kv, 100,000 kva; 14.4 kv, 250,000 kva; and 23 kv, 250,000 kva. Copies of this publication are available on request from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

Electrical Precipitation. Research-Cottrell, Inc., Bound Brook, N. J., has published a 28-page bulletin on its electric precipitation equipment. The bulletin describes the general principles of electric precipitation, and individual sections of this bulletin are devoted to its chief applications. Installations, photographs, and diagrams supplement the text.

Oil-Tight Push Buttons Bulletin. A new bulletin describing the complete line of oil-tight push buttons, selector switches, and accessories is available from the General Electric Company, Schenectady 5, N. Y. The 4-color 16-page publication contains information on product features and applications, and complete ordering directions for push buttons, lights and combination units, operators, contact blocks, name plates, stations, and accessories. Designated *GEA-5779B*, the bulletin also contains dimensions and outlines, plus contact ratings, of all units.

Battery Selection Techniques. Bulletin *210* contains battery selection techniques for standby power, emergency lighting, and switchgear applications. A discussion of charging equipment and simplified battery maintenance techniques are also included. Installation procedures are described and illustrated. Copies of this 20-page manual may be obtained by requesting Bulletin *210* from Department SP 665, Exide Industrial Division, The Electric Storage Battery Company, Box 8109, Philadelphia 1, Pa.

Kodak Technique Described. Techniques for the production of etched circuits and name plates utilizing Kodak Photo Resist are described in a new leaflet offered by the Eastman Kodak Company entitled "Etched Circuits and Name Plates With Kodak Photo Resist." Step-by-step methods applicable to the manufacture of both etched circuits and name plates are described. Write Graphic Arts Sales Division, Eastman Kodak Company, Rochester 4, N. Y., for copies of this publication.

UHF
. . . Ultra High Frequencies

RADIO INTERFERENCE
and FIELD INTENSITY*
measuring equipment

Stoddart NM-50A • 375mc to 1000mc

Commercial Equivalent of AN/URM-17

ULTRA-HIGH FREQUENCY OPERATION . . . Frequencies covered include UHF and color television assignments and Citizen's Band. Used by TV transmitter engineers for plotting antenna patterns, adjusting transmitters and measuring spurious radiation.

RECEIVING APPLICATIONS . . . Excellent for measuring local oscillator radiation, interference location, field intensity measurements for fringe reception conditions and antenna adjustment and design.

SLIDE-BACK CIRCUIT . . . This circuit enables the meter to measure the effect of the peak value of an interfering pulse, taking into account the shaping due to bandwidth.

QUASI-PEAK FUNCTION . . . An aid in measuring pulse-type interference, the Quasi-Peak function is just one of the many features of this specially designed, rugged unit, representing the ultimate in UHF radio interference-field intensity equipment.

ACCURATE CALIBRATION . . . Competent engineers "hand calibrate" each NM-50A unit. This data is presented in simplified chart form for easy reference.

SENSITIVITY . . . Published sensitivity figures are based on the use of the NM-50A with a simple dipole antenna or RF probe. However, the sensitivity of this fine instrument is limited only by the antenna used. The sensitivity of the NM-50A is better than ten microvolts across the 50 ohm input.

Stoddart RI-FI* Meters cover the frequency range 14kc to 1000mc

VLF
NM-10A, 14kc to 250kc
Commercial Equivalent of AN/URM-98. Very low frequencies.

HF NM-20B, 150kc to 25mc
Commercial Equivalent of AN/PRM-1A. Self-contained batteries. A.C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies.

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NM-30A, 20mc to 400mc
Commercial Equivalent of AN/URM-47. Frequency range includes FM and TV bands.

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